THE ROMANCE OF MEDICINE

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BY

JOHN A. HAYWARD
M.D., F.R.C.S.

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TO THE

KING EDWARD'S HOSPITAL FUND

AND TO MY SON

JOHN HAYWARD

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PREFACE

SINCE my retirement from practice in 1930 I have kept up an interest in professional matters by giving occasional talks or lectures on behalf of the King Edward VII's Hospital Fund for London, as a part of its scheme of propaganda. The talks, generally illustrated by lantern slides, have been given chiefly at Schools, Public, Private, or National, to boys and girls aged fourteen to eighteen, but also to older audiences at Polytechnics, Settlements, and Institutes.

Their subject matter has been for the most part the progress of Medicine, preventive and curative, during the last century, and its establishment on scientific foundations; with the great discoveries which constitute landmarks, and have altered our outlook; and what is going on at the Hospitals, and in the Public Health Service at the present time.

Although to grown-ups there is apparently nothing more engrossing as a subject for conversation than illness, or disease, especially the one or many peculiar to themselves, I was astonished to find how eager these younger audiences were to hear about Hospital work, new discoveries, and what can only be described as the Romance of Medicine.

In the short time of a lecture, necessarily sketchy in character, much had to be left unsaid, or unexplained; and the time afterwards allotted to questions was never sufficient to satisfy genuine interest and intelligent enquiries, apart from the posers put by those who wished to display their own knowledge!

The purpose of this small and unpretentious book is to amplify the talks and lectures that have been given

for King Edward VII's Hospital Fund, in the hope that it may stimulate interest in Hospital work, and Public Health, and possibly be useful to young adults of either sex, who after their school days, may be thinking of entering on a career of Medicine or Nursing, or one of the callings associated with them.

There is a further aim which may appeal to older people. The more widely advances in Medicine are understood the better, and some of the following pages may furnish material for thought.

There are, for example, preventive measures against many diseases, and means for the improvement of national health and physique, which do not so much await further discoveries, as a popular determination to make those already known effective.

For audiences of both descriptions I have found that greater interest is aroused if the talk or lecture is more or less in the style of a story, and as far as possible the same plan has been adopted in the following pages, viz. the telling of a tale which will claim, if indeed such claim be needed, that advances in Medicine have at least kept pace with the marvellous discoveries in other branches of science during the nineteenth and twentieth centuries.

Many of these medical discoveries read like fairy tales, and perhaps one day a medical Kipling may arise to do justice to the little cells of which we are made, and how they work, and will sing or tell of the Homeric battles and the weapons with which they carry on a never-ending war with disease.

The description of Medical progress would, I thought, be made clearer by its arrangement into contrasting periods; (1) The Pre-Scientific; (2) The Scientific. There are, of course, no such hard-and-fast distinctions in its history; from the earliest times the scientific

method based on observation and experiment can be discerned amidst a welter of theory and superstition, and at the present time the *practice* of Medicine is more an art than a science, more empirical than rational. Nevertheless since the seventeenth century there has been a gradual tendency towards scientific method. One of my chief objects has been to describe the debt which Medicine owes to the exact sciences for discoveries which have been adapted to its use ; and accordingly the Scientific period of Medicine may be considered as more or less contemporaneous with this closer relationship.

Miss G. A. Gollock in her admirable book, *Heroes of Health* (Longmans, 1930) has told for young people the life of self-sacrifice and devotion of those who have made many of these discoveries ; such men as Pasteur, Lister, Manson, and Ross, or those who, like Lazear, and Hall Edwards, sacrificed their lives in furthering their work.

David Masters, too, in the *Conquest of Disease* (Bodley Head, 1925) has described in an attractive narrative, which the layman can well understand, the evolution of Medicine, and the discoveries made by the pioneers.

To these two authors, no less than to Professor Singer's *Short History of Medicine* (Clarendon Press, 1928) and to Dr Wyndham Lloyd's *A Hundred Years of Medicine* (Duckworth, 1936) I am indebted for a large part of the subject matter. The labour of referring to ordinary text books has been relieved by the delight of reading again those Medical Classics, *Life of Pasteur* (Vallery Radot), *Life of Lord Lister* (Rickman Godlee), *Sir Patrick Manson* (Manson Bahr), and the discovery of a delightful piece of literature under the unpromising title of *Vitamins*, by W. R. Aykroyd (second edition, Heinemann, 1936).

I am indebted to the kindness of Professor Sir Walter Langdon-Brown, for reading the typescript and for helpful

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I am especially grateful to my wife for undertaking the burden of reading the proofs, and for her help in the indexing, and to my son John Hayward for his emendation of the manuscript. Without his assistance and advice this book could hardly have made its appearance.

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[1] In later references abbreviated K.E.F.

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A Short History of Medicine, Professor Charles Singer (Clarendon Press).

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John Brown Buist, Professor T. J. Mackie and C. E. Van Rooyen (*Edinburgh Medical Journal*, Vol. XLIV).

The drawing "Battle of the Boil" was made by T. Poulton, Esq., from a rough sketch.

Last but not least I must express gratitude and thanks to my publishers for their courtesy, indulgence, and generosity in carrying out without demur all my suggestions, especially as regards the illustrations, and for their encouragement and advice as the book took shape.

PREFACE TO SECOND EDITION

I HAVE been encouraged to prepare a second edition of this book as it appears to have found some favour with many young people, who, after leaving school, are thinking of taking up Medicine or Nursing as a profession, or who have become volunteers in the Red Cross or St John Ambulance Services, or are interested or engaged in various branches of Social work.

The present Edition may also be of some use to Teachers and Instructors who are giving classes in First-Aid or Social Health Services, and to others who have a general interest in Hospital and Medical Research work.

Its design aims at nothing more than the arousing or stimulation of interest, by a brief sketch of the life and achievements of the great Medical Pioneers, and giving some general account of the advances and discoveries made in Medicine during the last and the present centuries, due in large measure to adaptations from the exact sciences of Chemistry, Physics, Biology and Bacteriology.

Moreover since the first edition was published not only have many further important discoveries or adaptations been made, but the War is changing our entire outlook on matters of health and environment, and the Beveridge Report and the issue of the Government White Paper envisage changes which will profoundly affect, not only our social conditions, but also the future prospect of the Medical and Nursing professions.

Together with enlargements in the chapters which deal with Blood Transfusion, and Nursing, four fresh chapters have been added on " Asepsis and War Surgery ", " Viruses ", " Chemotherapy ", and " Social Medicine "

including "Venereal diseases" and the scope of the epilogue has accordingly also been widened.

I am indebted for helpful criticisms and suggestions to

Dr F. Hobson, M.D., F.R.C.P., D.S.O., of Oxford, on the subject of "Chemotherapy";

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All the illustrations of the First Edition have been reproduced, with the addition of a picture of the microbe of Syphilis from Dr Singer's *Short History of Medicine*, by courtesy of the Clarendon Press, Oxford.

PART I

PRE-SCIENTIFIC MEDICINE

Chapter I

COMPARISON OF ANCIENT AND MODERN MEDICINE

In order to appreciate modern methods of treatment of disease, by the work that is going on in Hospitals, or in its prevention by the care of the State under the general term Sanitation, it is necessary to gain some idea of the conditions which obtained when Medicine had but the slenderest of claim to be considered Scientific in its methods or outlook.

Even at the present time, Medicine has been called, somewhat sneeringly, the "Handmaid of Science", but rather is she in the position of an Employer, enlisting to her service many branches of Physics, Chemistry and Biology, and adapting in her instruments some of the most exquisite devices of Mechanics; and it is through the use she has made of these Sciences that progress has been made and the outlook enlarged.

It was, however, far otherwise until about a hundred or more years ago, at the beginning of the nineteenth century.

Although these were the "good old times" of which we so often hear and read, most of us probably consider ourselves fortunate that our lot has been cast in the present age, at any rate from the point of view of all that concerns our health.

From the purely intellectual point of view it might seem attractive to have lived before the present age of Science in one or other of the two preceding great

epochs of human progress ; either the Greek civilization, 400–200 B.C., predominant in Philosophy, Art, and Literature, or in the Renaissance Period, A.D. 1400–1700, when the Revival of Learning took place and Modern Science was born ; but in both of these great periods compared with our own it was a bad time to be taken ill. A man, then, was indeed lucky if he survived his infancy, and, after that, his expectation of life was very much less than at the present time, and sickness or accidents were often attended with horrible pain and suffering.

Nowadays Science attends us at our birth, or even beforehand ; we are born more easily, and with less distress to our Mothers ; we are shepherded through infancy and childhood under the strictest rules of hygiene and with due regard to our psychology ; we are fed on vitamins in addition to a properly balanced diet of " carbohydrates " (sugars and starches) ; proteins (nitrogenous foods) and fats ; our tonsils, adenoids and appendices are removed on the slightest provocation ; we can be inoculated or vaccinated against many infections ; our schools are medically inspected ; and all through our lives the Health Authorities safeguard us by various Sanitary regulations. If in spite of all this we do fall ill, or meet with injury, we can get skilful treatment at home or in a well-appointed Hospital, and if our case is a difficult one our doctor can call in some branch of Science such as Physics, Chemistry, or Bacteriology, to aid him in diagnosis or treatment. Nor will he rest there. In case he fails and we die in spite of his care, he will almost certainly be able by a post-mortem examination to find out really what was the matter, and what might have been done ; a discovery, which, if not equally as satisfactory to our relatives as to himself, may further the cause of Science, and be helpful in similar

cases. Is not the apt motto of the Pathological Society, "Nec silet Mors"? (Nor is Death silent.)

It would be outside my purpose to trace the evolution of Medicine from the earliest times down through the dark Middle Ages to the birth of Science in the fifteenth, sixteenth and seventeenth centuries. It is sufficient to say that while its practice was still based on the discoveries and writings of the ancients, especially the great Founders of Medicine, Hippocrates (500 B.C.), Aristotle (300 B.C.), and Galen (A.D. 200), it had become debased by all sorts of theories as to the causes of disease. These theories were not founded on facts, observation, or experiment, but owed their origin to ingenious speculations in the mind of the thinker in his endeavour to build up a comprehensive "System" embracing all diseases and so forming a convenient foundation for their treatment.

We still use in describing temperaments or dispositions the terms "Sanguine" (full blooded); "Phlegmatic" (dull-watery); "Choleric" (fiery, due to yellow bile); "Melancholy" (depressed, due to black bile); to an excess or deficiency of which the majority of diseases were attributed under the old system of bodily "Humours". Any unfortunate patient had to fit in with the fashionable "System" in vogue, and undergo the appropriate treatment, whether Sweating, Blood-letting, Purging, Dieting or what not. Anything outside the "System" was wrong and contrary to orthodox medical usage. Traces of this point of view exist even at the present time.

At the Revival of Learning, A.D. 1400–1700, Medicine shared in the impulse, and began to realize that knowledge and progress could only be gained by discarding speculations, and relying on facts ascertained from observation and experiment, and during these centuries the foundations of Medical Science were laid.

What are these foundations? They are, (1) The

science of Anatomy or the Structure of the healthy body. (2) Physiology, the science of the functions of the bodily organs, and tissues. (3) Pathology, the causes of disease and its effect on the structure and functions of the body.

It must be remembered that the early Medical Scientists had to rely almost entirely on their unaided senses in their observations and experiments. Physics, Chemistry, and Bacteriology, had not yet come to their aid, and their mechanical instruments were of the simplest and most primitive kind. The microscope invented by Galileo in 1609 was a simple lens, and the compound microscope with its high powers and clear definition remained very imperfect until the latter part of the nineteenth century. In Clinical or Practical Medicine, the Stethoscope, for aiding the ear, only came into use in 1819, and the clinical thermometer for taking the body temperature about 1840–50.

Anatomy. Physiology. Pathology

At the beginning of the nineteenth century the Science of Anatomy was already well advanced, and the naked-eye structure of the body ascertained, chiefly through the teaching of the famous School of Anatomy at Padua in Italy, established by Vesalius in the sixteenth century, and the genius of our own John Hunter (1728–93), who founded the great Museum of the Royal College of Surgeons.

Physiology was in its infancy, and little was known of the functions of the internal organs of the body with the exception of the wonderful discovery by Harvey in 1628 of the circulation of the blood. Pathology, or the cause and effect of disease, was only in process of birth, limited by the lack of aid from Chemistry, Physics, and Bacteriology, and the still imperfect microscope, although

its foundation had been laid by Morgagni of Padua (1682–1771), who had made many exact descriptions of the appearances after death of different classes of disease.

Clinical Medicine

If these were the conditions which existed in regard to the purely Scientific side of Medicine, what was the state of its application to Practice, or as we say "Clinical Medicine"?

Clinical Medicine comprises (1) Diagnosis, or the ascertainment of the nature or variety of an illness. (2) Prognosis, the outlook, or course it will pursue. (3) Treatment, by prevention or remedy.

Among the first to place these three on a rational basis was the great English physician, Sydenham (1624–80), who, discarding all theories and "Systems" and routine treatment, based his practice on the *individual* treatment of each patient and on his particular temperament, after making his diagnosis by careful examination and his prognosis by the light of accumulated past experience.

But with such imperfect knowledge as then existed of the essential causes of illness, and with little help from other branches of science, not to mention very clumsy instruments, how powerless was a doctor with little but his own senses on which to place reliance! He might for instance have to treat a patient for a "fever"—a *symptom* common to a number of different illnesses not at that time distinguished, and requiring different treatment, just as rheumatism to-day is a *symptom* due to different causes not yet discovered. And so with the majority of complaints with which he was confronted.

Under such conditions treatment was necessarily directed to the relief of the *Symptoms* of a disease, not to its essential *Cause*, and the wisest Physicians were those

who let well alone, and aided natural recovery by mild measures, instead of by active interference such as purging, sweating, cupping, and bleeding, which were then so much in vogue. This practice indeed holds good at the present time where the actual cause of an illness is not known. All we can do then is to relieve the symptoms, trusting to the natural powers of the body to effect a cure. This reliance on Nature was the very precept advocated by that wisest of Physicians, Hippocrates, more than two thousand years ago, and the Science of to-day fully confirms his maxims as will be seen later in discussing Modern Methods of Prevention and Treatment. This attitude of mind is also well illustrated in the saying of one of the greatest Surgeons, Ambroise Paré, in the sixteenth century, " I dressed his wounds, God healed them."

It must not be forgotten that, then as now, patients and their friends had a profound faith in medicines, herbals, and quack remedies of all kinds, and vast quantities were prescribed and swallowed, since no treatment was considered complete without a bottle of "stuff". These methods have always been a source of considerable profit to doctors, chemists, and patent medicine vendors, and faith in drugs has declined but slowly even since the introduction of more rational forms of treatment.[1]

It would be a mistake to judge the old Physicians and Surgeons as less clever and able than those of the present day. In many respects they were more so, for the reliance on their unaided senses cultivated in them an almost uncanny instinct in diagnosis and prognosis, and

[1] In a recent speech (1936) at the annual conference of the National Association of Insurance Companies at Bournemouth, the Minister of Health stated: " In twelve years the number of prescriptions annually issued in England and Wales (National Health Insurance) had increased from 38,200,000 to 62,400,000, and the total cost from £1,325,000 to £2,100,000."

their treatment was guided by an accumulated experience gained from accurate observation and stored in the memory. Nowadays, relying largely on delicate tests, chemical and bacteriological, made by others in the laboratory, and with aid from Röntgen rays, electricity, and many other sources, the modern doctor has less chance of attaining the wonderful clinical insight of his forbears, and their confidence in their own powers.

Chapter II

SURGERY, MIDWIFERY, PREVENTIVE MEDICINE, TROPICAL DISEASES

Until comparatively recent times Surgery was considered an inferior branch of the profession. The Physician practising pure Medicine held a superior status. Before the establishment of the Royal College of Surgeons in 1800, the Corporation of Surgeons had been combined with that of the Barbers under the Charter granted by Henry VIII. However, during the seventeenth and eighteenth centuries the practice of Surgery, in the hands of a number of distinguished men, had been gradually emancipating itself from this association, and a very high degree of skill had been reached by the beginning of the nineteenth. Even so, from the modern aspect it would at that date appear to have been almost barbaric in practice. The application of boiling oil to prevent infection of wounds, and of the red-hot iron to stop bleeding, had indeed been supplanted by the use of dressings and ligatures, but essential progress was barred by the limitation of means to overcome the agonies endured by the patient, and consequently of the duration of any operation which required prolonged technique; but most of all by the disastrous results which so often followed operations of all kinds, however simple, and however skilfully performed. Infection of both accidental wounds, and of those made by the Surgeon, followed almost as a matter of course. Suppuration of wounds was the rule and not the exception and was even encouraged. The dread scourge, however, was the gangrene and generalized infection which caused death in some 50 per cent. of compound fractures,

and with all the precautions then known carried off so large a proportion of all operation cases. It was known as " Hospital Gangrene " because it was common in any ward where surgical cases were collected together.

It makes one almost sick to read the descriptions given of this state of affairs in the Hospitals until the latter half of the nineteenth century. The stench, the groans, the delirium of the dying ; the helplessness of doctors and nurses in the presence of this mysterious infection which snatched away their patients, spoilt all their skill and care, and defeated every effort to overcome it. Even when cleanliness and better ventilation and less overcrowding had effected some improvement, a ward would suddenly become infected and the dread Visitation pursue its course from bed to bed. Little wonder that people dreaded going into Hospital.

A word indeed had been coined to account for the greater risk incurred by going into Hospital than by treatment at home. The extra risk was summed up in one word " Hospitalism ", a vague term for the various infections rife in Hospitals. This was regarded as quite a satisfactory explanation of a prolonged illness, or even death of a patient, just as the doctors and nurses were so accustomed to the stench of the wards, that they felt at home in what was recognized as a " good old surgical stink ".[1]

An appropriate inscription over many of these Institutions might well have been that of Dante's Inferno, " All Hope abandon ye who enter here."

Under such conditions the range of Surgery could only be limited, and consisted chiefly in the amputation of limbs, at which the Surgeons were great adepts ; removal of growths and tumours, and of stone from the bladder, trephining the skull for fractures, and opening abscesses.

[1] Sir R. Godlee, *Life of Lord Lister*, p. 131 et seq. (Macmillan, 1917.)

To open a joint, or the abdomen, or the chest, meant almost certain death from subsequent infection, and was seldom attempted ; nor had the delicate technique been evolved which is required for intestinal surgery, or the removal or repair of internal organs and structures. As it was, an operation of any magnitude must have been a dreadful affair for patient and surgeon alike. Deadening

FIG. 1. AN OPERATION IN THE SIXTEENTH CENTURY
(Reproduced by the courtesy of the Clarendon Press from *A Short History of Medicine* by Professor Charles Singer)

drugs like opium were sometimes used to lessen the pain, but were not effective to control the involuntary struggles of the patient. And there was the mental dread beforehand, the horror of being held or strapped down, the consciousness of all that was going on, the agony of the sawn bone, the after collapse. If the operation itself was successful, there was subsequently the pain of the dressings during a long recovery, and the very probable

chance of mortification of the wound, and a fatal result from a generalized infection.

And the Surgeons! What sort of men must they have been—such as Larrey the Surgeon of Napoleon's campaigns, or the Ship Surgeons in the cockpits at Trafalgar? Any tenderness of heart they felt must have been kept under stern repression; conscious of the pain they were inflicting and the necessity for haste, they must have needed nerves of iron and undaunted resolution to carry out their work. Speed and manual dexterity were their chief assets, in order to get the operation completed in a few minutes, and send the patient back to bed alive. Frequently a Surgeon's reputation was proportionate to the number of seconds in which he could amputate a limb or remove a stone from the bladder.

MIDWIFERY

Here again the conditions were akin to those of Surgery. The mortality of mothers in Lying-in Hospitals was much greater than in their own homes, owing to the frequent infections of Puerperal Fever which devastated these Institutions, and sometimes carried off as many as 20 per cent. or more of the cases. In the Paris Maternity Hospital as late as 1856 out of 347 confinements that took place in ten days, 64 proved fatal, and very similar figures were recorded at the General Lying-in Hospital in London and other capital cities.[1]

As in the General Hospitals, greater cleanliness, ventilation and lessening of overcrowding might effect some improvement but did not stamp out the frequent and unaccountable visits of the infection. When we consider the rate of mortality from this cause in the last century, the present scare (1937), because the maternal mortality

[1] Master's *Conquest of Disease*, p. 91.

FIG. 2. LYING-IN SCENE—SIXTEENTH CENTURY
(Reproduced by the courtesy of the Clarendon Press from *A Short History of Medicine* by Professor Charles Singer)

rate has remained stationary for some years at about *5 per 1,000*, seems hardly justified. There can be little doubt that with the researches now being carried out, and with the prospect of improved conditions of medical and nursing services, this figure will be still further reduced.[1]

INFANT MORTALITY

The mortality rate of infants under one year, and of children under five was enormous. Even as late as 1896–1900, out of every 1,000 children born alive, 156

[1] See Chapter xx, *Social Medicine Statistics.*

on the average died during the first year. In 1931 the rate had been reduced to 66 per 1,000.[1]

Epidemic disease, especially Measles and Whooping Cough, was largely responsible for this terrible death rate, but still more so was it due, then as now, to social conditions; poverty and hopeless ignorance of the principles of nutrition, and the proper upbringing and feeding of infants.

PREVENTIVE MEDICINE

Although " Prevention is better than Cure " is no less a medical than a popular maxim, in Pre-Scientific days up to the middle of the nineteenth century, with the scanty knowledge of the actual causes of epidemic and other diseases, very little had been done in this the most important branch of Medicine.

A vast amount of preventable bodily disease existed, apart from infectious diseases which were always more or less present and often occurred in epidemics, bringing devastation to town and country. This was largely due to the prevailing social conditions. A fatalistic state of mind was universal. We take the ordinary circumstances of life for granted and become callous to dangers if they are of everyday occurrence, as for example in war, siege, or even the common road disasters of to-day.

Epidemics were mostly looked upon as scourges sent by the Almighty for our sins, and like Old Age, or Death, inevitable. But from very early times certain ideas had existed about *Contagion* which was thought to be a "*miasm*", or exhalation, in and around the body of an infected person, and in times of Plague, Smallpox, and

[1] Wyndham Lloyd, *Hundred Years of Medicine*. See Chapter xx, *Social Medicine Statistics*.

other epidemics strict rules of isolation and for the disposal of the dead were enforced. Lepers, for instance, from the earliest days had been compelled to live outside the community.

Apart from this precaution, there was, through want of knowledge of its importance in regard to disease, an almost total disregard for General Sanitation, including drainage and the disposal of sewage, the supply of pure water, removal of refuse, ventilation, overcrowding, lighting, and for insanitary dwellings, factories and Institutions. Windows were kept shut to exclude fresh air and avoid chills, and the night air was considered especially dangerous, and still further guarded against by the curtains drawn round the four-post beds. The filthy streets of the towns, with open drains; overflowing cesspools contaminating the wells; the unremoved garbage, and abominable smells, were on a par with the general absence of personal cleanliness even among the upper classes. It might be uncomfortable but it was no disgrace to be verminous, and it was probably for the *former* reason that the fashion of shaving the head and wearing a wig came into vogue.

Consequently when an epidemic of any kind occurred it spread far and wide under these favouring conditions. Beyond the isolation of patients and infected houses, and regulations for the disposal of the dead, little could be done in visitations of epidemics, and treatment other than symptomatic was futile.

It is curious that with the devotion to all that pertained to antiquity in philosophy, art, literature and the classical studies at the Renaissance, so little attention was paid to the example set by ancient Rome in its *sanitary* customs, regulations and appliances; the cleaning of the streets and open places; the great cloaca or sewer; and the magnificent aqueducts capable of supplying 300,000,000

gallons of pure water daily for drinking, and for the elaborate public baths.[1]

In addition to the common infections—Measles, Scarlet Fever and Diphtheria—Smallpox, Typhus and Typhoid Fever were endemic, that is to say always present, but liable to break out in epidemic form from time to time. Of these Smallpox was the most disastrous. As late as the eighteenth century it accounted for one-tenth of the total death rate, and a great amount of blindness. Comparatively few people escaped an attack, and so prevalent were its disfigurements that among the descriptions issued for the tracing of a criminal, might be the *absence* of scarring on the face.[2]

Typhus (Gaol Fever), and Typhoid or Enteric Fever had not been distinguished from one another until 1837. The former was especially common wherever overcrowding occurred in combination with lack of sanitation and cleanliness, e.g. in prisons, barracks, and the packed dwellings and tenements of the poor. It was stamped out by general sanitary measures largely owing to the reforms in prison conditions initiated by the work of John Howard (1726–90). The carrier of the infection is now known to be the body louse, and by simple measures of ensuring cleanliness of person and surroundings, gaol fever ceased to exist, though its cause was not discovered. Typhoid or Enteric Fever was present everywhere and at all times among rich and poor, the clean or dirty. I have heard it stated that, as late as 1866–70, in estimating the value of a medical practice, one of the considerations to be taken into account was the average number of cases of typhoid per annum ! The disease, conveyed in food and drink, or by carriers, still remains with us but is now of rare occurrence, as its cause, a microbe, is known,

[1] Singer, *A Short History of Medicine*, p. 46.
[2] Master's op. cit., p. 35.

and the source of infection in an outbreak can usually be quickly traced.

But the most terrible of the epidemics of former days, and which still occurs at intervals in the Far East, was the Plague or Black Death. Invasions from time to time spread over Europe and literally wiped out millions of the inhabitants. The most serious visitations in England occurred in 1348 when nearly 2,000,000 out of a total population of 6,000,000 succumbed ; again in the reign of Queen Elizabeth ; and lastly in the Great Plague of 1665, when over 100,000 of the citizens of London fell victims. The cause was entirely unknown, but as it appeared to be contagious, strict rules for isolation of infected patients and houses, and for the disposal of the dead, were enforced. It required the drastic disinfection of the Great Fire of London before the epidemic ceased, and the subsequent rebuilding did away with large areas of slums and insanitary houses. Quarantine or a period of isolation for forty days for vessels coming from infected foreign ports had been instituted as far back as the fourteenth century in Venice and the Adriatic, and later became generally adopted in other countries.

A remarkable instance of voluntary isolation was that of the whole village of Eyam in Derbyshire in the 1665 epidemic. The Plague had been conveyed from London, and, at the instigation of the Vicar, the inhabitants agreed to shut themselves off from the outside world until its ravages had ceased. Food was left for them at appointed places, and for a whole year the community kept themselves away from adjoining villages, and no one was allowed to enter. At the end, only 33 out of 360 inhabitants remained alive.[1]

Yet another scourge which has its home in the East is Cholera. Serious epidemics of this infection occurred

[1] *Conquest of Disease*, p. 155.

in Europe and England during the nineteenth century, carrying off many thousands of people. It spread to Great Britain in 1832 when 50,000 deaths were recorded ; the total mortality in the epidemics of 1849–54, 1866, was lower, but of those attacked in the latter year (14,378) there were 5,596 deaths.[1]

By the middle of the nineteenth century, a national sanitary sense had been aroused, and these visitations of cholera gave rise to a considerable degree of panic, and were largely instrumental for focussing attention on the state of the towns, slum housing, defective drainage and water supply ; and for the subsequent introduction of legislature which initiated the Public Health Service of modern times. Although the cause of Cholera was unknown until Koch's discovery of the germ in 1883, experience had shown that isolation, disinfection, and a pure water supply were the chief safeguards.

Enough has been said to make clear the point that in the Pre-Scientific period of Medicine, before the essential causes of many diseases and epidemics were known or suspected, the conditions of life, especially among the poorer classes, and the general lack of Sanitation, were largely responsible for the existence of disease of all kinds and the ravages of epidemics. Experience had already taught the need for isolation in contagious complaints, and the higher rate of disease and mortality under the unsanitary conditions of overcrowded towns was gradually arousing a national conscience that all was not well, and directing attention to drainage, water supply, housing, and the hygiene of factories, hospitals, prisons, and Public Institutions of all kinds.

Since, however, every disease has its particular cause, and requires special methods for its prevention, and these were as yet unknown, it was not until Scientific

[1] Cholera Statistics (*Ency. Brit.*, 1911).

Medicine, especially Bacteriology, had discovered the origin of many of them, that really effective measures could be taken to attack them at their source.

TROPICAL DISEASES

This reasoning is particularly applicable to diseases peculiar to the Tropics, and to others like Malaria and Dysentery which, though at the present time chiefly confined to those regions, were formerly of quite common occurrence and swelled the death rate in temperate zones, including Great Britain, until the end of the eighteenth century. Before that time practically nothing was known of the true cause or methods of conveyance of these and other Tropical complaints such as Plague, Yellow Fever, Cholera, Sleeping Sickness, and a host of others less wide in range and confined to particular areas. Among the native races the occurrence of these diseases, and the death rate, were exceedingly high, more especially from Ague, or Malaria. Among the white population they were appalling.

The most unhealthy places were Central America, the West and East Indies, and all Tropical Africa, especially the West Coast round about Sierra Leone, which was known as the "White Man's Grave". To be sent there on service almost amounted to a death sentence. Those who survived a residence in the Tropics came home with wrecked health to drag out a miserable life which was ill compensated by any fortune they may have made.

In Jamaica, the mean annual mortality of the garrison was for many years 185 per 1,000; and at Sierra Leone 362 per 1,000. The cause of the majority of Tropical diseases was attributed to the unhealthy atmosphere—"*Malaria*", an Italian term—just as influenza was a bad "influence" possibly due to unpropitious planets,

comets, " blights ", or other astrological or atmospheric reasons.[1]

Although the real agent was unknown, better sanitation and drainage were gradually eradicating Malaria in England, which until recent years was of quite common occurrence in East Anglia and the Fens.

More fatal than Malaria or Ague in its percentage mortality (50 per cent.) was Yellow Fever—or Yellow Jack as it was called—which decimated both natives and whites in Central America, the West Indies, and West Africa, and in spite of quarantine regulations was often conveyed from port to port by trading vessels. The conditions on board a vessel infected with Yellow Jack have been well portrayed by Marryat in the *Flying Dutchman*.

By reason of its rapid course, distressing symptoms, and high mortality, Yellow Fever was far more dreaded than Malaria, and no better illustration of the direful effects of these two diseases could be given than the history of the attempt of the French Government in the early 'eighties to construct a canal across the Isthmus of Panama. The great undertaking was placed in the hands of de Lesseps who had made the Suez Canal, and something like £50,000,000 was spent in equipment, machinery, transport and labour. The work went on for nearly eight years, but had to be abandoned, partly for financial reasons, but chiefly on account of the dreadful mortality from Yellow Fever and Malaria which killed off the gallant French engineers and workmen, one after another, to the number of 20,000. As will be seen in a later chapter, it was an insignificant insect, the mosquito, which held up the building of the Canal for more than twenty years, until in 1900 the American Medical Commission at Havana in Cuba discovered how the infection

[1] Singer, *A Short History of Medicine*, pp. 277–80.

was conveyed. When the American Government, armed with this knowledge, took over the construction of the Canal in 1909, the disease was very quickly stamped out.

In addition to the diseases already mentioned—Plague, Malaria, Yellow Fever, Cholera, Dysentery—the big five—there are numerous other tropical diseases, limited more or less to particular countries, islands, or areas or continents (e.g. Sleeping Sickness in Central Africa) which for the most part are parasitic in origin.

In Pre-Scientific days and until their particular mode of conveyance was ascertained, the ordinary rule-of-thumb safeguards of Isolation and General Hygiene were insufficient to cope with their ravages. The story of the self-sacrifice, labour, ingenuity, and indeed heroism, incidental to many of the discoveries, fills some of the most inspiring pages in medical history, and brings an atmosphere of romance into the laboratories, with their microscopes and test tubes, their cultures and incubators, and into the lives of unceasing toil and patience of the workers with their hopes and despairs.

Chapter III

HOSPITALS

Hospitals can be traced back to very early times. Down to the seventeenth century they were mostly religious foundations intended for the reception of the poor and needy as well as for the sick.

In Greek and Roman days there was a regular class of priest-physicians who served at the Æsculapian temples, and marvellous "cures" were made by supernatural methods such as the induction of dreams, or by suggestion, or incantations, as well as by dieting and drastic medicines. High fees, or votive offerings, were paid for these benefits by the wealthy, but there were also the "Valetudinaria" or Infirmaries for the sick poor or slaves, besides military hospitals for soldiers.

It was, however, the growth of Christianity that gave such an immense impetus to the establishment of Hospitals, Hospices, and other Institutions, for travellers, outcasts, and the poor, as well as the sick, in every country, province, or large town to which the Faith had spread. It forms the brightest record of the otherwise dark Middle Ages under the dismal influence of Ecclesiasticism on scientific progress. Pious founders, from pure goodness of heart, or anxious to compound for sinful lives with an eye to the future, often built or left endowments for the upkeep of Hospitals or similar Institutions; and the Voluntary System under which our present-day Hospitals are run is a direct outcome of this irresistible appeal of Charity and Penitence. Excluding monasteries, there were more than 750 charitable institutions in mediæval England.[1]

[1] R. H. Clay, *The Mediæval Hospitals of England* (1909).

The best example perhaps is the great Hospital of St Bartholomew in Smithfield. It was founded in 1123 by Rahere, a courtier in the reign of Henry I. While on a pilgrimage to Rome to atone for his sins, he was visited in a dream by the Saint, who instructed him to build a religious foundation on " Smoothfield ", a waste piece of land belonging to the King, just outside the City walls.

Rahere obtained a grant of the land, and built both a Priory of which he became the first Prior—(on the site of St Bartholomew the Great) and a Hospital in connection with it (St Bart's Hospital). The connection lasted until the dissolution of the monasteries by Henry VIII, who endowed the Hospital, and in 1547 gave it by Charter to the Lord Mayor and Citizens of London, when it became an entirely secular Institution.

The Hospital was entirely rebuilt in 1730–59, and at various times large additions have been made to meet more modern requirements. The Medical School dates from 1662, and since 1549 when three surgeons were appointed to visit the wards, some of the greatest physicians and surgeons of their time, including Harvey, Abernethy, and Paget, have served on the staff, and as teachers in the school.

It is sad to have to relate that the first physician to be appointed, Dr Roderigo Lopez, a Court Physician, though of foreign extraction, was hanged, drawn, and quartered at Tyburn for his supposed complicity in a plot to murder Queen Elizabeth.

Before its severance from the Priory the Hospital admitted outcasts of every description, the aged and needy as well as the sick, and was served by the monks. A Master, eight brethren and four sisters, who were Nuns of the Augustine Order, were appointed to look after the inmates and their numbers were gradually increased.

A great founding of Hospitals took place in London in the seventeenth and eighteenth centuries. St Thomas's in 1693, Guy's 1724, and the Westminster, St George's, and the London Hospital between 1719 and 1743. During the nineteenth century, special hospitals, Maternity, Children's, Eye, Nose and Throat, Skin, Consumption, came into being in different districts. The provinces, too, were not behindhand ; during the same period, hospitals equalling those in London were built in most of the large cities, and towards the latter part of the nineteenth century, smaller towns, and townships, established their Cottage Hospitals.

The vast majority of all these Institutions owed their origin to private benevolence, and were and are mainly supported by voluntary subscriptions and benefactions.

Work in the Old Hospitals

What were the conditions, and what kind of work went on in these Hospitals in the Pre-Scientific days?

I have already alluded to the state of surgery and the horrors of the operating table ; the overcrowding, the high mortality, and the consequent general dread of "going into hospital". This was not surprising, for even if a patient was sent into a medical ward he or she would almost certainly be bled, blistered, sweated, or purged to an alarming extent, whatever the complaint might be. One or other of these treatments was almost a routine procedure. Bleeding or cupping was employed in almost every case and not infrequently was used, in pre-anæsthetic days, to induce such a degree of faintness that the setting of a fracture, or reduction of a dislocation, might be rendered more bearable for the patient, and easier for the surgeon to manipulate. Another method of bleeding was the use of leeches. It seems incredible,

but at St Bartholomew's Hospital in 1822 no less than 52,000 were used, at a cost of £187, and by 1837 the number had reached 96,300! In this year the in-patients numbered 5,432, and out-patients 50,000.[1]

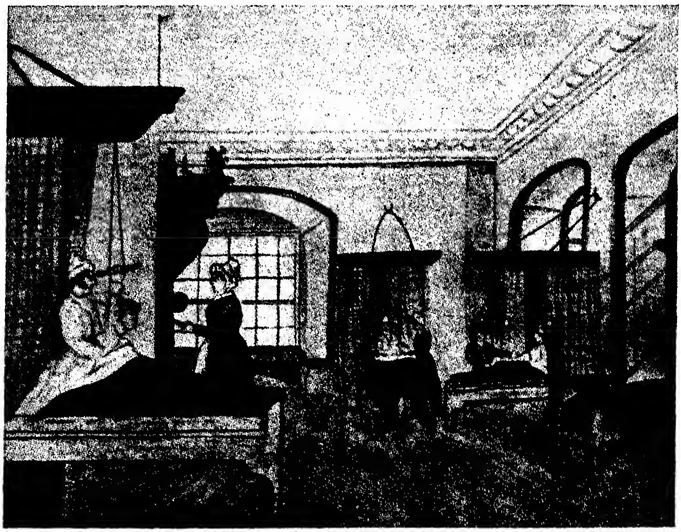


FIG. 3. OLD WARD IN HOSPITAL
Rahere Ward at St Bartholomew's Hospital in 1832, from a Contemporary Drawing
(By courtesy of Sir D'Arcy Power, K.B.E., F.R.C.S.)

Linseed for poultices, a favourite form of treatment for both medical and surgical purposes, was used by the ton; and an enormous quantity of medicine of all kinds was prescribed and swallowed, among which Magnesium Sulphate, or Epsom Salts, held pride of place to the extent of about 2½ tons per annum. Doubtless it was the national demand for this salt, as well as its extravagant

[1] Sir D'Arcy Power (idem, p. 51).

use at St Bartholomew's, which exhausted the springs and diminished the former prosperity of the fortunate town of Epsom, happy however in its possession of yet another claim to fame.

In Hospitals with Medical Schools, the students, who also had to serve a term of apprenticeship with a practitioner, " walked the wards " and received instruction at the bedside, and attended lectures given by the physicians and surgeons. Anatomy and Physiology were usually learnt at private establishments outside the Hospital, and consequently there was great competition among the owners to procure " subjects " for dissection. Before the passing of the Anatomy Act in 1832, which regularized the procedure, this state of affairs gave rise to the illicit traffic of " body snatching ", or even to the committing of murders (e.g. the case of Burke and Hare at Edinburgh). Botany and Pharmacology were also taught and a certain amount of naked-eye Pathology.

Yet the most striking difference perhaps between the " pre-scientific " Hospital and its modern equivalent was the absence in the former of the highly equipped laboratories, for scientific research, for the instruction of students, and the examination of material and specimens sent from the wards for reports to aid in the diagnosis and treatment of the patients. Another striking difference is to be found in the absence of " special departments " for different classes of disease, or for affections of particular organs, such as the Eye, the Throat, or the Skin, which under modern conditions form so important a feature of all large hospitals. The old-time physician or surgeon undertook the treatment of all classes of disease in all the parts of the body, and the reign of the " Specialist " had not yet begun.

A word must be said about " out-patients ". In the old days, as at the present time, their numbers formed

one of the chief problems of hospital administration. Accommodation was never sufficient, and adequate examination and treatment impossible. In 1878 at St Bartholomew's the number reached 250,000 and this was maintained for many years.[1] The vast majority of these attended for minor complaints, and in such a crowd of daily applicants it was no small difficulty to "spot"

FIG. 4. OUT-PATIENTS, GREAT ORMOND STREET CHILDREN'S HOSPITAL—"ANXIOUS MOTHERS"
(By courtesy of King Edward's Hospital Fund)

the really important cases and retain them for careful examination, and get rid of the others as quickly as possible. In the immense Waiting Room, there would often be a regular babel of tongues, especially on the women's side. An ancient story tells of a certain official who was accustomed to quell the disturbance by calling on each row of patients to stand up and put out their

[1] Sir D'Arcy Power, *History of St Bartholomew's Hospital.*

tongues and *keep them out.* Silence in this way being obtained, he would then pass down the rows giving to each patient one of six differently coloured tickets, which indicated the appropriate medicine for that state of tongue, and armed with this symbol the gossip was sent to the dispensary to have her bottle filled, and so left the hospital. It is said that very few disasters occurred !

Another interesting tale which illustrates how the custom of " free medicine " may be abused was told to me by the late Sir W. Church, physician to the Hospital. " An old lady attended the Out-Patients Department regularly once a week (and, as it was found out, at other hospitals as well) to obtain Confection of Senna, heroic doses of which, she declared, were essential to keep her in health. She was a pleasant old lady and liberal allowances of the remedy were supplied. A hospital official, however, recognized her one day presiding at a street stall in the East End, where she was doing a roaring trade by the sale of " Aperient tartlets " which consisted of a teaspoonful of the confection on a little round of pastry—(price 1d.)." After an admonition and a reduction of her weekly allowance, she was permitted to continue attendance.

Reform of the Out-Patient Departments is rapidly taking place in the modern hospital.

PART II

SCIENTIFIC MEDICINE

Chapter IV

THE DISCOVERY OF VACCINATION FOR SMALLPOX

Edward Jenner, the son of the Vicar of the village of Berkeley in Gloucestershire, was born in 1748, and after he had become qualified as a doctor settled at his birthplace as a country General Practitioner. As a boy he was remarkable for his accurate powers of observation and devotion to Natural History, and spent most of his leisure in geologizing, or collecting and arranging specimens of birds, beasts and insects, or making notes of their habits. In addition to these tastes he was a good musician and singer, and wrote tolerable verses. We must picture him, therefore, as a man of general ability; and he appears also to have been a favourite in society and a leading personality among the neighbouring doctors.

As a medical student in London he had the immense advantage of living as a pupil in the home of John Hunter, the most eminent Surgeon of his time, who was then engaged in the formation of the great Museum which is now in the possession of the Royal College of Surgeons.

Hunter became much attached to young Jenner, noted his ability, and by his encouragement and advice both during his pupilage, and in after life in their correspondence on matters of scientific interest, rendered him great service.

While still in London Jenner was offered an important post as Naturalist to an overseas expedition, but he loved his native Gloucestershire and preferred to settle down as an ordinary country doctor.

In the second chapter mention has been made of the dreadful scourge of Smallpox, which apart from its occurrence in serious epidemics was always present more or less, and hung like a sword of Damocles over every household, and in all countries. In England it was nearly as common as is measles at the present time. One attack was known generally to confer immunity for life from another, and so dreaded was it, that the practice of inoculating the poison from a mild case, or exposing people directly to that type of infection, was frequently adopted, in the hope that permanent immunity might be obtained at the diminished risk of a slight attack. The disadvantage of this practice, which had been introduced from the East by Lady Mary Wortley Montague, in the early part of the eighteenth century, was that even a mild form of the complaint in one case sometimes gave rise to a severe form in another, and so many deaths occurred, that it was prohibited by law in 1840.

Such was the state of affairs when Jenner started in practice about 1775. Now, although it is not always wise to discredit popular beliefs or even old wives' tales, of the thousands of remedies which have owned their renown to such recommendations, I can call to mind only three that have stood the test of time or scientific investigation.

1. The belief of the natives of Peru that Cinchona bark, from which quinine is extracted, was a cure for Ague or Malaria (it was so named after the Countess of Chincon, a Spanish lady who brought it to Europe; or it was sometimes called Jesuit bark, owing to its wide use and dissemination by the priests of that order).

2. The belief of the same natives that the coca plant (from which cocaine is extracted) when chewed acted as a physical and mental stimulant.

3. The belief in certain country districts in England, that cowpox, a mild complaint, the chief symptom of which was a spotty eruption on the hands and arms of milkers, protected against smallpox. Cowpox in the cow is characterized by the occurrence of small blisters on the udder and teats; milkers get infected, and in a few days, a similar eruption appears on the part of the body which has been in contact; general symptoms are absent or very slight, and the eruption soon dries up and disappears.

Jenner had thought a great deal about these country tales in his student days. He had discussed them with John Hunter, who encouraged him to pursue the subject, and by observation and careful records of a number of cases to try to ascertain if indeed there were any foundation for this popular belief, which had never been accepted by the medical profession. He set this purpose before him when he started his practice, and for more than twelve years he made careful records of all the human cases of cowpox he could find, personally or by enquiry, and their freedom or otherwise from an attack of smallpox.

Armed with these statistics, which fully confirmed the rustic legend, he came to London in 1788 to announce his discovery. It was received by the great doctors of London with indifference and incredulity; they were far too obsessed with their own importance to listen with interest to anything that could be discovered by a country practitioner, or which had originated in a country superstition of ignorant farmers and housewives. Besides, the crucial test had never been performed of inoculating genuine smallpox virus or poison into a person *previously* inoculated with cowpox, or who had had a natural attack.

This last was certainly a pertinent criticism, and though discouraged, Jenner went back to Gloucestershire, and started on another ten years of work convinced that he was on the right track, though he was much hampered by the disappearance for a time of any cases of cowpox among patients, or cattle.

He was quite unaware that a Dorsetshire farmer, named Jesty, had actually in 1774 inoculated his family with cowpox to prevent them, as he hoped, catching the smallpox then prevalent in his district. Jesty therefore has a prior claim to have been the first to perform vaccination. His attempt, however, was entirely a shot in the dark and not like Jenner's due to induction from observed facts and confirmed by experiment.

At last in 1796 the opportunity occurred. Trusting to the accuracy of his observations, he summoned up courage to inoculate a boy of eight years with smallpox, having a few weeks previously inoculated him with cowpox obtained from the arm of a dairymaid who had caught the complaint from a cow. They, as well as Jenner, deserve some share of fame ; the boy was James Phipp ; the dairymaid Sarah Nelmes. James remained free from smallpox after the inoculation. Delighted with this result, Jenner proceeded to vaccinate many more cases with cowpox with lymph taken from the blisters of cowpox patients, and soon afterwards either inoculated them with smallpox, or brought them in contact with others in an active stage of an attack.

Whichever of these two methods of inducing an infection of smallpox was adopted, none of those who had been previously vaccinated with cowpox caught the major complaint.

Finally in 1798 he published the results of his observations and experiments in his celebrated treatise, " An enquiry into the Cause and Effects of ' Variolae Vac-

cinae' " (smallpox of the cow), and again came to London. Even with these complete and convincing results his discovery was again received with incredulity by the London doctors.

The great John Hunter, whose influence might have helped, was dead, and had it not been for the strenuous advocacy of an open-minded surgeon—Henry Cline of St Thomas's Hospital—who confirmed some of Jenner's experiments, there might have been many more years of waiting before the truth was revealed. Through Cline's influence an astonishing and rapid success very soon came to the discoverer. The news spread like wild-fire that here at last, by a simple little operation, a remedy had been found for this pestilential and horrible disease. Nor was Jenner's triumph seriously affected by some setbacks caused by the failure of others to imitate his methods and obtain similar results. The general excitement was not confined to England alone; the good news spread to the Continent, and very shortly over the whole world.

In 1803 Spain sent out an expedition, which spent three years travelling over its great possessions in the New World, to initiate the practice of vaccination. Other European countries received it as one of the greatest blessings yet conferred on humanity. Germany kept Jenner's birthday as a feast. The Roman Catholic countries made it an occasion for religious processions; and last but not least, by the wish of the Empress it was decreed that the first Russian infant to be vaccinated should be educated at the public expense, though to be sure this stroke of good fortune was perhaps somewhat clouded—from the child's point of view—by the stipulation that thereafter he or she was to be named "Vaccinov!" [1]

Jenner is one of the few Englishmen who have shed

[1] *Encyclopædia Britannica*, 11th ed., "Jenner".

honours on their country, and have received official recognition and reward in their lifetime. Parliament voted him a grant of £10,000 in 1804, and another £20,000 in 1806. The University of Oxford conferred on him the degree of M.D., but it was left to the Royal College of Physicians to signify the exclusiveness of that august Corporation by the refusal to admit him for election until he had passed its preliminary examination in *Classics*. This he declined to do, conscious perhaps that he had already passed a sufficiently severe test in a somewhat wider branch of the "humanities". He died in 1823. Statues in his memory have been erected in Gloucester Cathedral and in Hyde Park.

After-Results of Vaccination Discovery

What have been the effects of this great discovery?

(1) It brought to light a sure method of controlling the epidemics of smallpox which occurred so frequently, and of stamping out the disease altogether if certain precautions, the importance of which was not realized until after Jenner's time, were adopted. Vaccination with cowpox lymph, does not, like an actual attack of smallpox, confer immunity for life. The protection afforded diminishes after a few years and it is necessary to be re-vaccinated in early adult life, and at least once afterwards, if complete immunity is to be gained. If this course were universally adopted smallpox would cease to exist for want of a favourable soil.

Of the efficacy of vaccination there can be no doubt. A Royal Commission (1889–96) went fully into all the details and statistics, and after exhaustive enquiries their Report fully confirmed the almost general faith of the medical profession in its value. It is not necessary here to discuss or examine all the evidence, though two rather

convincing points may be mentioned. (1) Ever since the establishment of smallpox isolation hospital ships at Dartford, there has been no instance of a single doctor, nurse, or attendant contracting the complaint. All have been protected by efficient vaccination. (2) In the epidemic of 1871 in London the death rate from smallpox was 242 per every 100,000; in Berlin 632 per 100,000. In Germany *re-vaccination* was made compulsory in 1874; in 1879 there was another epidemic and the figures show: London 71 deaths per 100,000, Berlin only 0·4 per 100,000.[1]

Vaccination, no doubt, is a nuisance. In infancy it makes the baby fretful and upsets the household; it interferes with arrangements, and the playing of games when the age comes for re-vaccination; and compulsory vaccination is, of course, an infringement of the liberty of the subject! For these reasons, and also because there are many who are convinced that any subsequent trouble from which they suffer dates from their vaccination, or who object to "nasty stuff" from a calf being introduced into their bodies, vaccination has become unpopular and has given rise to the anti-"vaccinationists" and "conscientious objectors".

As a consequence, the previous Compulsory Vaccination Acts of 1853–71 were modified, to suit the objector, in the Act of 1898, with the result that a large proportion of our population is unvaccinated, and so provides a favourable soil once an epidemic has started.

Prompt isolation of the first case (if recognized) is no doubt a safeguard, but the tracing of all contacts is a matter of great difficulty, and the infection before this can be done may have been conveyed to distant places. The announcement of a case of smallpox therefore leads to a scare and a rush for vaccination which should have

[1] Masters, *Conquest of Disease*, p. 45.

been performed years beforehand; as, for example, in the epidemic of 1901–4, when supplies of reliable lymph were almost unobtainable.

In the past the unpopularity of vaccination was not altogether unreasonable. The details of the preparation of a pure lymph, and of the operation itself, were only slowly evolved, and occasionally bad results followed, the most common of which was severe inflammation of the arm from sepsis incurred at the operation or afterwards. The practice, too, of using lymph from arm to arm was thoroughly unsound, though the conveyance thereby of any disease was an extremely rare occurrence.

For many years the Government have undertaken the supply of pure glycerinated calf lymph prepared under the most rigorous precautions in their laboratories. The doctors who act as Public Vaccinators are thoroughly versed in the proper technique of the simple operation; Nurses and Health Visitors attend at the homes to give advice and help with the after-care, so that vaccination is now freed from any reasonable prejudice, and its evasion is comparable to the non-payment of income tax. Those who elude it throw a greater burden on those who, in the public interest and security, comply with the demand—for the latter have to share in the expense and disorganization caused by an epidemic which would never have occurred had there been no defaulters.

The Principle of Immunity

(2) But the most important consequences which followed long after the discovery of vaccination, and of which Jenner was unaware, were the light which it has thrown on the principle of *Immunity*, and the impulse it gave in after years to the study of those *natural* safeguards against disease and infections which our bodies possess,

and of the means by which those safeguards can be induced or imitated by artificial means. Cowpox, or Vaccinia, if not identical, is so closely akin to smallpox that for all practical purposes it may be considered as the same disease, modified in its virulence to human beings by its passage through the cow. When it is transferred to man it is capable of protecting him from smallpox for a period of years at the cost of a very slight disturbance. The organism or germ responsible for either complaint has not yet been identified ; so minute is it that it eludes the highest powers of the microscope, and can pass through the finest filters.[1] Nevertheless we know something of its character and effects, and that it possesses life since it is capable of reproduction.

What is it in the cow that performs this most useful function for us, which mitigates the poison, and yet does not take away its powers to confer protection ? As we shall see in a later chapter (Chapter VI, page 58) it was this line of reasoning which led Pasteur, familiar as he was with Jenner's work, to make his classic experiments on the " attenuation " or mitigation of bacterial poisons, and by their injection into animals and man in gradually increasing strengths, to afford protection against the infection from which they originated. The body reacts or responds to the weakened poison and gradually manufactures its own antidote to such a degree that it becomes invulnerable to even a fatal dose of the original infection. Since Pasteur's time, numerous workers in Biochemistry and Experimental Pathology have sought to solve the problem, which is still one of the mysteries of our living bodies. Many important discoveries have been made,

[1] Minute particles, known as the " elementary bodies " of Paschen, or Buist, found in both smallpox and cowpox lymph, are considered by many observers as the virus of these diseases. (Mervyn Gordon, " Virus Bodies ", *Edinburgh Medical Journal,* Vol. XLIV, 1937. See also " Viruses ", Chapter x.

the results of which have revolutionized our conception of disease, and the means to be employed in its conquest, nevertheless it is no exaggeration to say that it was Jenner who laid the foundation on which in recent years so many brilliant achievements have been built.

Chapter V

THE DISCOVERY OF ANÆSTHETICS, AND LATER DEVELOPMENTS

The dread of pain is a primary fact of our existence, and suffering is not lessened by the philosophy of regarding it as a salutary danger signal which warns us that something is wrong with our bodies, and requires immediate attention ; for indeed without this warning we should be in constant danger of worse injury or even death. But philosophy of this sort is a poor form of comfort for even such a minor pain as the toothache, still less in the agony of a severe accident, the incision of an operation, the sawing of a bone, or the surgery of our internal organs.

Probably the commonest question a doctor has to answer in regard to any illness or operation relates to the amount of pain it will give.

Is it possible then for our imagination to grasp the amount of pain that mortals had to suffer before the discovery of anæsthetics ; to realize what a different and more blessed world we are living in to-day, when, freed from the nightmare dread of suffering which once attended every surgical operation, the doctor is able to say : " You won't feel any pain at all " ? And not only this, but to realize that hundreds of operations, which were not possible before the days of anæsthetics, can now be performed with ease and safety.

Thus the discovery of anæsthetics forms the second great landmark in the Scientific Progress of Medicine.

From time immemorial there have existed ways for relieving pain by drugs or other methods, but none of

these comparable in effect with the complete unconsciousness, and insensibility to pain produced by an anæsthetic. Opium, Indian hemp, Mandragora, were well-known remedies in ancient times for sleeplessness, pain, and mental disturbance, and were often used to stupefy the patient before an operation. Shakespeare in "Othello" (Act III, Sc. 3) makes Iago say in his famous soliloquy:

> "Not poppy, nor mandragora,
> Nor all the drowsy syrups of the world,
> Shall ever medicine thee to that sweet sleep
> Which thou ow'dst yesterday."

Hypnotism, and bleeding to produce faintness, were also sometimes used before pain was inflicted, but these and other methods were very unsatisfactory, both in producing insensibility and abolishing the involuntary movements of the muscles. Such was the state of affairs in "Medicine" until less than one hundred years ago.

In 1800, when little more than a lad, Humphry Davy, the son of a woodcarver of Penzance in Cornwall, had found out that he could make himself unconscious by inhaling nitrous oxide vapour (laughing gas), and that it gave rise to queer dreams, followed by mental excitement as consciousness was regained. He was at the time apprenticed to a surgeon, but never qualified as a doctor, as he spent all his time in making experiments of every kind in physics and chemistry. Eventually he came to London, was appointed Lecturer at the Royal Institution and was made a Knight for his great services to Science. Davy had suggested that laughing gas would be serviceable in surgery, but no notice was taken of this proposition, and it appears to have been mostly used as an interesting "turn" at popular entertainments or lectures.

In 1844 Horace Wells, an American dentist, tried the gas on himself for a tooth extraction, and finding that

he suffered no pain, began to give it to his patients with great success ; but as its effects lasted only a few seconds its use became very restricted and almost limited to dentistry.

Earlier in 1829, Michael Faraday, the great electrician, had showed that *ether* was capable of producing unconsciousness, but Medicine made no use of the discovery until 1846, when another American dentist, W. Morton of Boston, after experimenting on himself, began to use it in his practice. As the anæsthesia was of longer duration than that given by laughing gas, it was tried with some success for a surgical operation, and the news reached England. This anæsthetic (sulphuric ether) had very serious disadvantages—an abominable smell, uncertain effects, great difficulty in administration—and it generally made the patient very sick and ill.

It was at this stage that Simpson came on the scene. Although the credit of the discovery, as in so many other instances, does not rest with one name alone, it was James Young Simpson, Professor of Midwifery at Edinburgh University, who in 1847 first definitely introduced anæsthesia by means of chloroform as a routine method of producing unconsciousness and insensibility to pain in surgical operations, or at childbirth.

James Simpson, the son of a Scotch baker, was born at Bathgate near Edinburgh in 1811, where his father was carrying on a not too flourishing business, and at times finding it difficult to make both ends meet. His mother was a far-sighted woman of great ability and industry, and as their boy from his early schooldays was devoted to his books and quick at learning, the parents, following a national tradition, determined that no effort should be spared to educate him for a more ambitious calling than their own.

He chose Medicine and at fourteen was entered at

Edinburgh University. As with so many young Scots under similar circumstances, his student days were a time of hardship, self-denial, and strenuous work, but he did brilliantly, was qualified as a surgeon at nineteen and passed the M.D. examination before he was twenty-one.

He appears to have been always peculiarly sensitive to the sight of suffering, and at one time gave up the idea of becoming a doctor, as he could hardly bear the agonizing scenes in the operating theatre, with the cries and struggles of the unhappy patients. However, he managed to overcome his weakness, and turned his attention to Midwifery with so much success, that after a strenuous and bitter contest, he was elected Professor at the University in 1839 when only twenty-eight years of age.

He became obsessed with the idea of finding some means for relieving the pains of childbirth, and for many years spent any scanty leisure allowed by an immense practice in making experiments on himself, with various volatile and other chemicals, in search of a compound which would produce a sufficiently long, safe, and complete state of insensibility. He took very serious risks which on more than one occasion were nearly fatal. He was also the first to make use of the sulphuric ether, previously mentioned, in midwifery, but realized its many shortcomings.

At last, in November 1847, his discovery of chloroform as an anæsthetic was made. This liquid had first been produced by the great German chemist, Liebig, in 1831, but it had been turned to no special use. Dumas, a celebrated French chemist, had been working at its composition, and knowing of Simpson's experiments, sent him a bottle of the heavy, sweet-smelling fluid which was put aside for a convenient opportunity to test it. This in Simpson's opinion came on an evening when two

of his colleagues had been invited to supper. The three agreed to make the trial at the supper table, and filling their glasses began to inhale the vapour.

We can imagine the scene that ensued : the gradual confused incoherence of their talk, the thrumming in the ears, the loss of control of limbs as the subtle effect stole down arms and legs, the inconsequent wandering into dreamland, and then the crash as they fell from their chairs and Mrs Simpson came rushing in to find all three unconscious on the floor. Fortunately for them the inhalation stopped when they fell and before the danger point had been reached, or a tragedy rather than a discovery would have been the consequence. History does not relate what happened to the supper, but Simpson was delighted with the result, and the vapour was tried almost immediately afterwards on a little boy who had to undergo a painful operation. The child quickly " went under ", and suffered no pain while the surgeon was able to perform a delicate and deliberate operation, freed from cries, struggles, or any disturbance. Very soon, Simpson began to use his chloroform in maternity work, with excellent results and with no apparent danger to mother or child, or interference with nature other than the relief of pain.

Assured of the success of his discovery he now published his " Account of a New Anæsthetic Agent ", and chloroform quickly came into demand.

There now arose a curious and unexpected outcome of this event, and, as with so many discoveries in Medicine, the use of anæsthetics met with some bitter opposition from the profession. It was undeniable that it had its dangers, and an occasional death during administration was enough to call forth the most alarming prophecies of the disasters in store at operations, and the risks of interfering with the natural course of childbirth. Simpson

was able to refute these arguments with his carefully recorded statistics; but the greatest opposition of all came from a large section of the lay public, on religious and ethical grounds, as directly contrary to Biblical teaching. It was affirmed that the lessening of pain in childbirth was doing away with the curse of Eve. "In sorrow shalt thou bring forth children"[1] and so on. Simpson neatly countered this argument by pointing out that "sorrow" is not synonymous with "pain"; and moreover God was merciful enough to anæsthetize Adam by causing him to fall into a deep sleep before removing one of his ribs!

It is difficult to understand why Simpson, after his own experience of the opposition of his fellow doctors to a new discovery, should have been later on in life one of the foremost to oppose the principle of the antiseptic treatment of wounds, discovered by Lord Lister. In his own case he was a good fighter and gradually wore down all opposition with the record of his results, and later on the use of chloroform was greatly popularized by its administration to Queen Victoria at one of the Royal births. It has in fact held its own as the anæsthetic *par excellence* down to the present day, though it is now almost entirely superseded by more modern methods which are considered safer and are unattended by the nausea and sickness which generally follow its use.

In the same year, 1847, in which he discovered the use of chloroform, Simpson was appointed Physician-in-Ordinary to the Queen in Scotland. A rather amusing story (for the truth of which I cannot vouch) is told in connection with this honour conferred on him, or it may be on one of his successors. It was considered by those in authority that the University itself as well as the recipient was honoured by this mark of Royal favour,

[1] Genesis iii. 16.

and immediately the announcement was received it was posted up on the notice boards devoted to Academic pronouncements. Very little time elapsed before an addendum appeared below the notice, written by some ribald student, " GOD SAVE THE QUEEN ".

Further Development of Anæsthetics

Allusion has been made to certain dangers attendant on the use of chloroform as an anæsthetic, chief among which are deaths from heart failure, or stoppage of respiration, disasters which among experts are of very rare occurrence—not more than 1 in 5,000. This small mortality, however, led to the continued use of ether in a purer form than the sulphuric compound, and the invention of a special inhaler by Clover in 1876 brought it again into popularity, for though unpleasant to inhale it is nevertheless safer than chloroform. It is not necessary here to discuss their respective merits beyond saying that if the after-effects of ether are taken into consideration, it is probably not very much safer in the long run than chloroform.

Anæsthesia by one or other of these vapours, with laughing gas for short operations or extraction of teeth, was practically the only method used until the early years of the present century. The administration of oxygen combined with laughing gas, by means of which a prolonged insensibility can be obtained, was a great advance. It is perfectly " safe ", pleasant to take, and has no ill after-effects, but it needs a cumbersome and expensive apparatus. In spite of this, thousands of lives were saved in the Great War by " gas and oxygen " as *the* anæsthetic for operations in which chloroform or ether would have added to the danger.

In the last few years still newer methods, among others

" Twilight Sleep ", have been introduced for producing different degrees of insensibility. The chemists have found out in their laboratories compounds, which when injected by a prick under the skin or into the muscles, or introduced into the circulation, will send us into a pleasant dream, or render us entirely unconscious and stop all movement or sensibility to pain for a long enough period to complete any ordinary operation, and all this with almost entire safety, and no ill after-effects.

It is simply a matter of a prick, a visit to dreamland, and waking up a few hours afterwards to enjoy a meal and resume life where it had been left off ; except that we are in bed and bandaged up. It would be out of place to describe the technique or enumerate these wonderful new drugs, but a word must be said about

Local Anæsthesia

A very striking advance was made in the latter part of the nineteenth century by the introduction of a method of rendering a *limited* area of the body insensible without any loss of consciousness, or risk to the vital organs. This was effected by an injection with a hypodermic syringe of a fluid drug which made the nerve or nerve endings supplying the area insensitive ; or in the case of a mucous membrane like the eye, nose, throat or mouth, simply by spraying or brushing the surface. This method was an immense advantage in the case of operations on these regions of the body, and even *major* operations can be performed on the trunk or limbs by the employment of a special technique, when a " general " anæsthetic is inadvisable. Cocaine, obtained from the coca tree, or " tree of life " as it was called by the natives of Peru, was the substance chiefly used, but of late years the chemists again have been able to produce various

synthetic derivatives which are even safer than cocaine and equally effective.[1]

A further development of this method early in this century was " Spinal Anæsthesia ". It was found that, by the injection of a few drops of one of these cocaine derivatives into the spinal canal, the whole of the trunk and lower limbs below the site of the injection could be made entirely insensitive and incapable of voluntary and reflex movements ; that complete consciousness was retained ; and, moreover, there were few ill after-effects beyond, perhaps, a headache. For certain operations this method is invaluable.

I well remember about 1905 my amazement when I first saw Spinal Anæsthesia employed at the West London Hospital. An old military veteran had to undergo a severe operation on the bladder lasting nearly an hour. After a painless prick in his back, a screen was placed to shut off from the patient's face the sight of the surgeon and his assistants at the lower end of the operating table. He was given a cigar to smoke, and in the intervals of his puffs, he regaled those assembled round the head of the table with tales of his experiences at the siege of Lucknow, and was quite unaware that a large tumour was being removed from the lower part of his body. After the operation he was carried back to the ward, had a good tea, and eventually made a good recovery.

It is worth recording such a case as it obviates any enlargement on the conditions which exist at the present time, contrasted with those which obtained before the days of anæsthetics, and to which I have already alluded.

Primarily it is the Science of Chemistry to which not only Medicine but the whole of suffering humanity is

[1] It may interest students of Chemistry (or others who are not frightened by long words) to learn that the name of one of these derivatives is "Stovaine" or Benzoyl-Ethyl-Dimethyl-Amino-Propinol Hydrochloride and its chemical formula C_6H_5CO, C_2H_5, CH_3CO, $CH_2N(CH_3)_2$, HCl.

indebted for this immeasurable blessing of the relief of pain, and the opportunity anæsthesia has given for the advance of surgery in all its branches, and the performing of hundreds of delicate operations formerly undreamt of, or thought impossible. The adaptation of these products of the laboratories to medical practice will nevertheless always be associated with the name of Sir James Simpson of Edinburgh, who first made use of chloroform and fought the battle of its introduction against prejudice and superstition.

To give a concrete example of the combined effect of anæsthetics, and a septic routine in the conduction of operations on the number and character of their performance at St. Bartholomew's Hospital, the following figures speak for themselves.

In 1885 with 397 surgical beds, the average yearly number of operations performed was 370, of which no less than 75 were amputations. In 1912, with 390 beds, the number of operations was 3,561, and of these only 25 were amputations.[1]

[1] Sir R. Godlee, *Life of Lord Lister*, p. 132. (Macmillan, 1917.)

Chapter VI

THE GERM THEORY OF DISEASE

Pasteur

The greatest discovery ever made in Medicine, and one that has altered our whole conception of the cause and nature of most diseases, as well as of their treatment, was chiefly due to the work of a French chemist, Louis Pasteur.

As a result of his researches between 1850 and 1890 the Science of Bacteriology was born, and its developments have extended into almost all branches of Science and their practical applications, and have profoundly affected our conception of life itself in its relation to the material universe.

Minute living particles of different shapes occurring in water and other fluids had been noticed as far back as 1683 with a primitive microscope, by a Dutchman, Van Leeuwenhoek, and their presence in fermenting and decomposing fluids was well known before the days of Pasteur. They were considered as the natural result and accompaniment of the chemical or other changes going on in the fluid, or as an impurity generated *de novo*—very much as most minute living creatures like maggots, lice, or other creeping, crawling things, even frogs, were formerly supposed to originate in dirt, or as a blight, or in the air, and come of themselves. It was a sufficient popular explanation of fermentation or putrefaction to describe it as an " influence " or a " working ", due to some special property in the leaven or wort ; and by learned chemists, like the great German, Liebig, it was

considered as a *molecular* phenomenon, which after all was only a longer name for the same idea.

The discovery of the part played by germs in the economy of Nature is as much an epoch-making event as Galileo's discovery of the true relation of the earth and other planets to the sun, or Newton's of the laws of gravity and motion ; and Pasteur's name is entitled to a place with theirs in the temple of Fame. For if Galileo revealed the nature of the infinitely great, no less did Pasteur reveal the nature of the infinitely small.

It is only possible here to give a very brief sketch of the life and character of this remarkable man—his lovable nature, his genius and insight in research, his incredible patience and labour, his devotion to Science and Truth. Every student in any branch of Science should read *The Life of Pasteur*, by René Vallery-Radot (translated by Mrs R. Devonshire. Constable & Co., 1902), which tells with absorbing interest not only the tale of his discoveries, and his battles with opposition, but reveals the beauty of his character and his love of humanity.

Louis Pasteur was born at Dôle in France in 1822. The Pasteur family were of humble origin and tanners by trade, and his father, Jean-Joseph, before settling in business had served as a conscript in the Peninsular War, had been decorated with the cross of the Legion of Honour for bravery, and promoted to sergeant-major. His mother, also of peasant extraction, was a woman of great intelligence, a capable manager of the household and full of imagination and ready enthusiasm. The French genius in many respects resembles that of the Scotch, and is especially marked in a trait common to both nations—the ambition and sacrifices of humble parents to educate their children and improve their position. Louis Pasteur as a boy was serious in disposition, studious and plodding rather than brilliant, with

a taste for drawing, and very accurate in observation. His parents who had settled at Arbois, sent him to be educated at the local College with the view to his obtain-

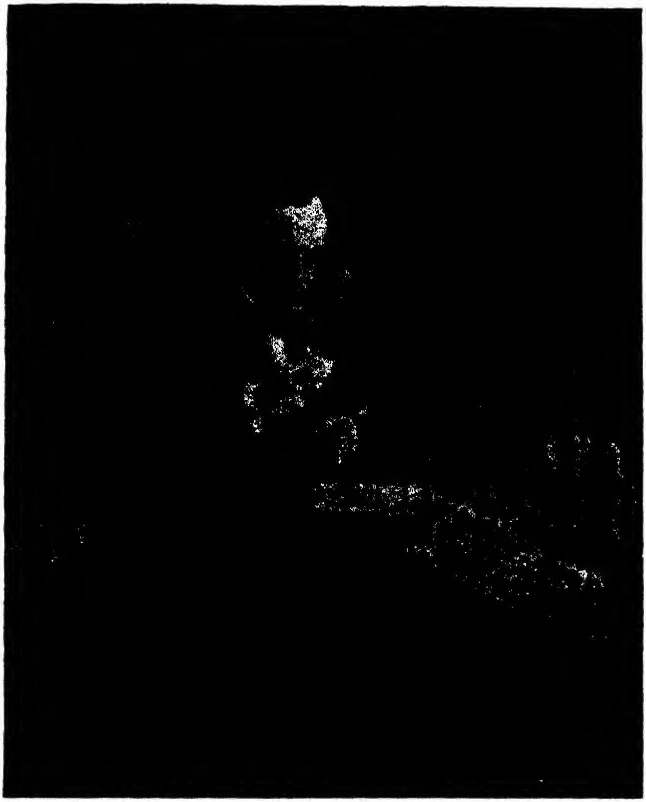


FIG. 5. PASTEUR IN LABORATORY

(From *Conquest of Disease* by David Masters, by kind permission of Messrs John Lane, Ltd.)

ing a degree. Like Simpson of Edinburgh, his life as a student was one of hardship, poverty, and strenuous work, sustained by the determination to repay his parents

for their affection and sacrifices. He did sufficiently well to be sent after examination to the École Normale at Paris, but became so homesick that he had to return to Arbois. A second attempt was more successful, and eventually he obtained his degree in chemistry and physics, but without distinction. For a time he made his living as a science master, and also engaged in improving the education of his own father by correspondence classes, but in 1844 he obtained the post of curator in the chemical laboratory of Professor Balard in Paris, and from this time onwards his career is marked by a succession of brilliant discoveries, as his particular genius in the field of original research found scope for its development.

One feature of his genius was the employment often of quite simple but new methods of attacking a difficult problem.

Researches on Crystals

This gave rise to his first discovery. Although the microscope was seldom used in chemistry, very accurate observation of the different formation of the crystals of tartaric acid and paratartaric acid, and their behaviour to polarized light, enabled Pasteur, when little more than a student, to solve a problem which hitherto had completely puzzled the most eminent professors of Chemistry and Physics.

The discovery at once brought him into notice, and before long he was made Professor of Physics at Dijon, and later of Chemistry at Strasburg, where he established his reputation as a teacher, as well as for original research. In 1855 he became Head of a new Faculty of Science established at Lille, with the special object of educating students in the application of science to the industries for which that city was famous, chief

among which were brewing and distilling, and it was at Lille that his great researches on Fermentation and Putrefaction began.

Fermentations of Beer and Wine

The story is well known. How the brewers and alcohol and vinegar manufacturers came and asked him to find out why their products went wrong and caused them grievous loss—how Pasteur over many years studied under the microscope the forms and reproductions of the little yeast cells in the various brews submitted to him ; how he devised methods of separating and cultivating them individually, and of killing them by heat ; and how he was then able to advise the way by which specific fermentations could be kept pure by proper methods of selection and sterilization ; and how above all he was at last able to demonstrate and prove that fermentation was *caused* by the life processes of these tiny yeast plants, which feed on starches and sugars, breaking them up into alcohols and carbonic acid gas ; that each yeast cell arises from a pre-existing cell, and that fermentation is a manifestation of life, and not a dead chemical organic change. He discovered too, the germs that are responsible for the souring of milk (the lactic acid bacillus), and the rancidity of butter (butyric acid bacillus). He demonstrated also how some germs (aerobes) can only live and multiply in the presence of oxygen, while others (an-aerobes) can do so only in its absence.

Spontaneous Generation

The fame of his researches brought him back to Paris as Director of Science at the École Normale, and he now entered on his famous experiments in disproof of the

theory of the Spontaneous Generation of living organisms in fermentations and putrefactions, which had been universally believed in until this date. The controversy raged for many years and aroused intense interest not only in scientific circles, but in its bearings on philosophy and theology. Pasteur was bitterly opposed, but he was able to point out the flaws in the experiments of those who controverted his own. His main object would be proved if he could demonstrate that it was not the admission of air itself which caused the growth of germs in a previously sterilized but putrescible fluid, but the *germs themselves* which were always present in the atmosphere except at great altitudes. Free the air from any germs, and then, in spite of its presence, any highly decomposable fluid, such as wine or infusions of meat, if sterile at the outset, would remain pure and free from any growth of living organisms for an indefinite period.

The method by which he demonstrated this great scientific truth was a triumph of simplicity and ingenuity. Taking a glass flask with a long narrow tubular neck bent downwards at an acute angle, he filled it half full with an easily decomposable fluid, and sterilized the flask, neck and contents, by heat. The flask was kept with the tube open at its end for many months in a still room, and though air could travel up and down the neck the fluid remained pure and free from life in any form. The explanation was equally simple. The germs in the air as they passed up the long, narrow, moist tube, were subject to gravity and became deposited on its sides, and thus never reached the fluid in the body of the flask.

By numerous experiments between 1860 and 1870 he was able to prove that all processes of decay, putrefaction, and fermentation are due to various kinds of germs, and that it was their part in the economy of nature to break up the complex molecules of dead organic

matter, whether animal or vegetable in origin, and resolve them again into the simpler elements, of gases, minerals and water. These were available in their turn to be built up into the bodies of plants and animals, and so complete the cycle of the destruction and renewal of life.

The adoption of his advice by the brewers and wine growers, who had learned from him the secrets of their industries, the significance of pure cultures, and the use of " sterilization ", resulted in the saving of some millions of francs ; and for this National Service and his work on Spontaneous Generation he was admitted as a Member of the Academy of Science in 1862. His reputation in Chemistry and its branch of Crystallography was already established ; by his latest researches he was opening out new fields of Science—Bacteriology and Biochemistry—dealing with the processes of life itself.

Silkworm Diseases

It was no doubt on account of these latest researches that he was asked by the Government in 1865 to investigate the mysterious silkworm disease which for the last few years had almost ruined the extensive industry in the South of France.

Pasteur knew nothing about silkworms, their culture, or diseases, and occupied as he was with his still incompleted work on fermentation, he only consented with great reluctance. The investigation in a branch of Science in which he had no training involved five years of the most strenuous work and experiment, and it needed all his scientific accuracy and powers of observation, and wonderful ingenuity in overcoming difficulties, before the problem was solved.

The disease—pébrine (so-called from the pepper-like

spots which appeared on the affected caterpillars and moths)—appeared to be contagious, and had spread to all parts of the world, which had already been searched for sound eggs. Most of the caterpillars died—the cocoons were of poor quality—the moths laid diseased eggs. Pasteur set to work. He dissected hundreds of the creatures in different stages of their growth, and discovered a parasite which was always present when disease occurred, and which was especially prevalent under improper methods of feeding from the mulberry leaves, or the housing of the caterpillars. After securing some disease-free moths, he had them strictly isolated, watched the development of their eggs, cultivated the caterpillars under improved conditions, and so on for successive generations, until he was sure the strain was free from the taint. Whenever more than 10 per cent. moths examined showed disease, all in that "magnanerie" or nursery must be destroyed, disinfection employed, and a new beginning made with pure eggs. All cultivators must be trained to use a microscope.

Such drastic measures met with fierce opposition, but Pasteur's methods, which are still in use, prevailed, and he had saved yet another industry for France.

Incidentally he discovered during this research, that another disease, "flachery" (flaccid), had been confounded with "pébrine", but was an entirely distinct infection due to a germ which inhabits the stomach and intestine, and gives rise to a kind of cholera. Isolation and disinfection as in pébrine were alone of any service, together with the use of eggs from disease-free moths.

Anthrax Disease in Sheep and Cattle

After his work on silkworm disease we find Pasteur gradually being led away from the path of pure Chemistry,

to the new sciences which he was creating, biochemistry, and bacteriology—especially in their applications to diseases of men and animals. Disaster befell him in the years 1865–8, for at this time he lost not only his father to whom he was devoted, but three of his daughters, and he himself had an attack of apoplexy which left him with a weakened left arm and leg; moreover, in 1870 there followed the disastrous war with Germany. But not even these misfortunes could extinguish his zeal to extend his researches to the discovery of the causes of infection, and their prevention or treatment. An opportunity was afforded in 1877 by the devastations caused in certain cattle and sheep districts by anthrax infection—a fatal disease which also attacks human beings (wool-sorters' disease). A rod-shaped microbe had been found in the blood of animals affected, both before and after death, but the results of its injection into healthy animals either after culture, or directly from infected blood, had been so variable and often contradictory in reproducing the disease that the proof was still wanting.

Pasteur very soon found out that the rod-shaped organism was the cause of the disease, and invariably caused death if injected into a healthy animal from the blood taken before or *immediately* after death of an infected animal; or from a *pure* culture taken at a certain temperature. Experiments by others had been vitiated by their use of impure cultures, or blood taken some hours *after* death, when it becomes charged with the septic germs of commencing putrefaction, which themselves will cause death by quite another disease (septicæmia), while the anthrax germs disappear. By experiments conducted over many months he worked out the life history of the anthrax bacillus; how it grew and needed oxygen for its multiplication, how it formed spores which resisted ordinary sterilization or deprivation of oxygen and might

remain dormant for long periods, and then sprang to life under favouring conditions of temperature, or food supply. He found out that certain pastures owed their bad reputation for anthrax to the fact that carcases of infected animals had been buried there long ago, but earthworms had brought the germs to the surface and infected the grass and thistles, and through the pricks the germs gained access to the bodies of the animals and brought about their death.

It was while making these investigations that Pasteur made one of his greatest discoveries which has had far-reaching effects in our conception of infectious diseases and their treatment. He found out that by keeping pure anthrax cultures at a temperature some degrees *higher* than that which best favoured their growth, their virulence gradually diminished and after a few weeks was entirely lost. It occurred to him (bearing in mind Jenner's cure for smallpox by the " vaccination " of cowpox, a milder disease) that he might effect a similar result in anthrax by injecting an animal with these " attenuated " (milder) cultures in gradually increasing strength, over a sufficient period, beginning with the lowest in the scale of virulence.

The experiment was performed and a series of these graduated viruses or vaccines was given to a sheep, which remained perfectly healthy when the fatal strength was reached, while an identical injection caused death within a few days to a " control " sheep which had not been so prepared.

A chance incident in some previous experiments which he was making in a fatal disease of poultry—chicken cholera—had suggested this idea. He had discovered the microbe responsible for the affection, and had been able to isolate it in pure cultures, and reproduce the disease by inoculating healthy chickens. The cultures were extremely virulent, and some were put aside for future use

while Pasteur was absent during a vacation. On his return he was disappointed to find that his cultures had ceased to grow, and when inoculated into fowls no longer produced the disease. Fresh cultures were made, and from these, inoculations were made both into fresh birds, and into others which had already been inoculated and remained unharmed by the non-virulent cultures. The fresh birds all died of the disease : the twice inoculated were not affected.

The Use of Vaccines

It was this chance result which might have been passed over by an experimenter with less insight—(Pasteur was fond of saying " Chance only favours the mind which is prepared "), that suggested to him the preparation and use of " Vaccines ", to render an animal " immune " against an infection. He called these preparations " Vaccines " [1] in honour of Jenner who had first introduced the idea of immunity, and this word as well as " Vaccination " has rather unfortunately fallen into use for designating *all* inoculations though they are in no way connected with a cow, or cowpox vaccine.

Pasteur's discovery of a " Vaccine " which would prevent anthrax caused a great sensation in France, and led to a dramatic climax. As usual it met with ridicule and opposition by those who failed to obtain similar results, and as the infection was decimating the herds in many districts, the authorities arranged that a definite trial should be made on an extensive scale. It took place at Pouilly-le-Fort, near Melun, in April 1881. Twenty-five sheep were to be first vaccinated and afterwards inoculated with virulent anthrax ; and similar inoculations given to twenty-five which had not been vaccinated.

[1] Lat. Vacca, a cow.

It was an anxious trial for Pasteur in case anything went wrong, but he was confident. As a result all the unvaccinated sheep died within three days. All the vaccinated ones remained quite healthy, except one which died from quite another cause.

The Germ Theory of Disease

In addition to these remarkable discoveries Pasteur had in 1877–8 recognized and cultivated one of the deadly germs which cause sepsis, or acute blood poisoning, in animals and men. He had found it in simple boils, in the bone marrow, and in cases of puerperal fever, but few of the medical profession gave the discovery any credence, or were willing to place any faith in a chemist who had gone outside his province and knew nothing of Medicine. Pasteur in April 1878, at a meeting of the Academy of Medicine, boldly gave a lecture on "The Germ Theory and its Application to Medicine and Surgery", and recounted his experiments. He concluded with a remarkable and prophetic warning: "This water, this sponge, that lint with which you wash and cover the wound, leave on it germs which will in a very short time cause the death of those operated upon unless the vitality of the tissues prevents the multiplication of the germs. If I had the honour to be a surgeon, convinced as I am of the dangers which microbes, scattered over the surface of all objects, threaten, especially in hospitals, not only would I use perfectly clean instruments, but after having washed my hands with the greatest care, and passed them rapidly through a flame, I would employ only lint, bandages and sponges previously exposed to a temperature of 110° C. to 120° C. All this is quite practicable." [1]

The discovery of virus-vaccines, and the work which

[1] L. Descour, *Pasteur and His Work.* (Fisher Unwin, 1922.)

had led up to it, had made Pasteur world-famous. He was accorded the *Grand Cordon* of the Legion of Honour. Foreign Universities conferred on him their honorary degrees, and he was admitted as one of the select forty who constitute the Académie Française, and represent the intellect of France. In England he represented France at the International Medical Congress in 1881, and received a popular ovation at St James's Hall.

Hydrophobia

It was in 1881 that he began the work for which he is best known, on Hydrophobia, in conjunction with Chamberland and Roux, his celebrated assistants in this and previous discoveries. It is impossible without entering fully into technical details to give any clear exposition of the difficulties and intricacies of this wonderful research. The germ which causes this terrible disease has never been found.[1] Although from its minute size it can pass through the finest of filters (Pasteur-Chamberland) and so belongs to the group of filterable viruses, Pasteur was able to prepare a vaccine which, if administered early enough after the bite, will infallibly prevent the onset of hydrophobia. The main points in this discovery were the following :

1. The incubation period before the infection develops after the bite is long and uncertain ; from a fortnight to perhaps several months.
2. The germ or poison is located in the brain and spinal cord.

[1] It is still undecided whether certain minute bodies (known as " inclusive or Negri bodies "), found in the nerve cells after death from hydrophobia, are collections of minute parasites, or are due to changes in the cell structure, or possibly both. Their presence is generally considered diagnostic of hydrophobia. (Park and Williams, *Pathogenic Micro-organisms*, p. 164. Baillière, Tindall & Cox, 1934.) See also " Viruses ", Chapter ix, p. 113.

3. Pasteur found he could shorten the incubation period to seven days, and produce a more virulent form of the disease by passing it through a succession of rabbits.

4. Taking the spinal cord of one of these "fortified rabbits" he dried it in sterile air, and found after each day a gradually diminishing virulence which disappeared altogether in about fourteen days.

5. He was then able to prepare from a cord a virus-vaccine of fourteen different strengths—the first of which would kill in seven days, the last being harmless.

6. By giving successive daily injections, beginning with the weakest, for fourteen days in increasing strength to rabbits or dogs, it was found that virulent first-day "vaccine" would no longer induce hydrophobia—and the animal remained free from any attack thereafter.

7. By thus being able to immunize an animal within fourteen days, he was able to forestall the onset from a bite of a mad dog, which takes a longer period to incubate. To ensure success, however, the injections must commence within at most a few days after the bite.

These researches extended over nearly five years till 1885 and then the crucial test came of applying this treatment to a human being.

Pasteur had succeeded in rendering no less than fifty *dogs* immune to injections of virulent rabies, but what would the effect be on little Joseph Meister, a boy of nine, who had been bitten severely by a mad dog sixty hours beforehand and had been brought to the laboratory? If he gave him the necessary injections and the boy did not react as a dog does, but happened to develop the disease, how could it be known whether his death might not be due to the injections rather than the original bite?

It was a dreadful responsibility, and ready to pounce upon him would be not only the horde of anti-vivisectionists, but many in the medical and scientific world who had opposed and belittled his work.

Encouraged by two eminent doctors, Pasteur decided to treat the boy, and for thirteen days the injections were made, the last being of full virulence. During these days Pasteur suffered great mental torture, and could hardly sleep or eat, but he was rewarded by the complete recovery of the boy from the bites, and no subsequent development of the dreadful disease. A few months later the same success attended the treatment of another boy—Jupille—who had been very badly bitten by a mad dog which he had bravely seized and held to prevent its attacking his companion, and then killed it by battering its head with his sabot. The bites had been made six days beforehand.

Then followed in 1886 the case of the nineteen Russian peasants, most of them dreadfully lacerated, who had been bitten sixteen days beforehand by a mad wolf. A mad wolf-bite was known to be almost invariably fatal. Three of them died—yet all the others recovered in spite of the long time which had elapsed before treatment was possible.

By March 1886 no less than three hundred and fifty bitten people had received preventive inoculations, with only one death ; whereas it had been computed that the former mortality after bites reached 40 per cent.[1]

His work on Hydrophobia was the culminating effort of Pasteur's life, but in spite of the world-wide interest aroused it met with some bitter opposition. A commission was sent from England to report on its efficacy, and after the most searching enquiry supported it in every detail, and this confirmation, together with a further series of successes established it on a firm basis. Pasteur had

[1] L. Descour, *Pasteur and His Work.* (Fisher Unwin.)

now reached the zenith of his fame. Not only France but many other countries wished to join in some permanent memorial to his honour, and it was decided to build in Paris an Institute which should bear his name and be a centre for bacteriological research as well as for the treatment of Hydrophobia.

The Pasteur Institute

The Institute was opened in 1888, and in its laboratories watching the work of the pupils he had trained—Roux, Chamberland, Metchnikoff and others—Pasteur passed the remainder of his days. His jubilee on his seventieth birthday in 1892 was celebrated by a great International Meeting of Scientists and Deputies from many countries at the Sorbonne in Paris. England sent Lister, who, inspired by Pasteur, had revolutionized Surgery by introducing the Antiseptic system, and the sight of these two great benefactors of humanity as they clasped hands aroused a scene of intense enthusiasm.

He died on September 28th, 1895, rewarded for all his toil by the knowledge that his life's work had opened a new page in human thought and given a fresh impetus to human progress. He had started a new era in Medicine and overcome traditional beliefs, and his disciples in all parts of the world were engaged on a conquest of disease along the paths he had indicated. His discovery of the part played by germs in Nature had initiated many new industries and saved many old ones, and as regards his own country well justified a remark of Huxley's: "Pasteur's discoveries have brought France more than the five milliards of indemnity paid to Germany after the war of 1870." [1]

[1] L. Descour, *Life of Pasteur*, p. 216.

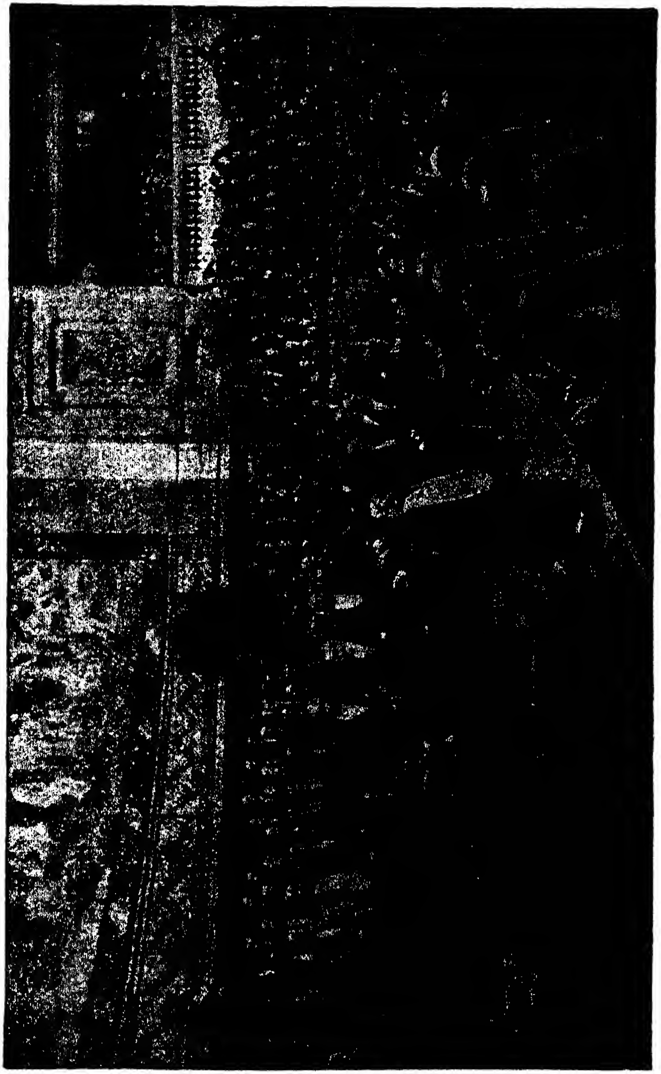


FIG. 6. LISTER AND PASTEUR AT JUBILEE, 1892, WITH PRESIDENT CARNOT
(From *Conquest of Disease* by David Masters, by kind permission of Messrs John Jane, Ltd.)

Pasteur's Character and Work

Pasteur's name will live in history, not only as one of the greatest men of Science, but as probably *the* greatest benefactor of human beings and animals in all that concerns their physical well-being. But any estimate must take account as well of his personality and character. As Roux, one of his ablest pupils, has written : "The work of Pasteur is admirable, it displays his genius, but it is necessary to have lived in his intimacy to understand all the goodness of his heart." [1] His chief characteristics were simplicity, a thirst for knowledge, love of truth, and absence of personal ambition. Any personal ambition of his early years became merged in an intense patriotism and a desire to bring renown to his country, and as he began to see visions of the possibilities foreshadowed by his discoveries, it became a passion to benefit humanity. He remained through life devoted to his humble relatives and old home. How different is the picture of him presented by some who are incapable of appreciating or judging what his work has brought to mankind ! To some he has appeared almost a monster, perpetrating unmentionable cruelties to gratify a thirst for knowledge or the lust of ambition. Pasteur indeed !—a man to whom men and animals are indebted for ever for discoveries capable of indefinite extension in the relief of disease and suffering ; a man who loved animals and could hardly witness an operation, much less perform one.[2] The sacrifice of comparatively few sheep or rabbits, mostly by the prick of a needle, or by operation under an anæsthetic, which has conferred lasting benefits on their own race as well as on ours, stands for nothing when

[1] R. Vallery-Radot, *Life of Pasteur*. Title-page. (Constable & Co., 1902.)
[2] L. Descour, p. 222, et seq.

compared with the thousands which suffer daily, in the knacker's yard, or die a slow and painful death in the wire snare, to gratify our appetite.

In reading the remarkable speeches which he delivered at his introduction to the Académie, and at his Jubilee at the Sorbonne, on his discoveries dealing with the origin of life, the transformations of death, and the mysteries of pain and disease, it is possible to discover his high ideals, and the belief which they had confirmed in him of an Infinite Power and Goodness manifesting itself in Natural Law, and the Conscience and Heart of Mankind.

He is buried in the Pasteur Institute, and the French with a characteristic delicacy of expression have deemed it sufficient to place on his tomb the simple epitaph: "Ici repose Pasteur."

Chapter VII

LISTER AND THE ANTISEPTIC SYSTEM

I have related in the last chapter how Pasteur, after his work on anthrax and the discovery of septic germs in "blood poisoning", announced his "Germ Theory of Disease" at the Academy of Science in 1878. But Joseph Lister, Professor of Surgery at Glasgow, had already forestalled Pasteur in this respect, by grasping in 1865 the significance of his earlier work on putrefaction in its application to the surgical treatment of *wounds*, and had begun to introduce the Antiseptic System which in its further developments was destined to revolutionize the practice of Surgery. Nor was its effect confined to Surgery; for Lister's work, and its successful results, were the strongest confirmation of the truth of Pasteur's Germ Theory generally, and gave an immense impulse to the study of germs, as causes of disease, by workers in all parts of the world. As a consequence, the specific germs responsible for a great many diseases have been discovered in the last fifty years, and scientific methods evolved for their prevention or treatment.

Lister came of a Quaker family and was born in 1827. His father was a Fellow of the Royal Society, distinguished for his knowledge of optics and the improvements he made in the microscope. Thus his son early in life came under scientific influences. He was educated at University College, London, and after his course at the corresponding Hospital, obtained his medical qualification in 1852. From the outset of his career he became interested in the healing processes of wounds and the various forms of inflammation, and studied with the microscope the dis-

charges and changes in the tissues which ensued after accidents and operations. There was no lack of material, for, as related in Chapter II, suppuration of wounds was considered as a normal event to be taken as a matter of course, while general sepsis and the dreaded hospital gangrene were of constant occurrence.

Lister became House-Surgeon in Edinburgh to the celebrated Surgeon, Professor Syme, whose daughter he afterwards married, and in 1861, at the early age of thirty-three, was appointed Surgeon to the Glasgow Infirmary. He was appalled at the state of the wards; they reeked with sepsis, suppuration, and gangrene. The mortality after amputations or in compound fractures was nearly 30 per cent., and it was almost hopeless to attempt operations on the joints, or abdominal organs, or the repair of delicate structures like nerves or tendons, where healing by "first intention" or "primary union", was essential. He instituted extensive reforms in regard to overcrowding, ventilation, and cleanliness at operations, and sent up the bills in soap. Some degree of improvement was effected but infection of wounds remained an everyday occurrence. He continued his researches with the microscope, and was becoming more and more convinced that these different infections originated *locally* in wounds and were not due to any constitutional condition,

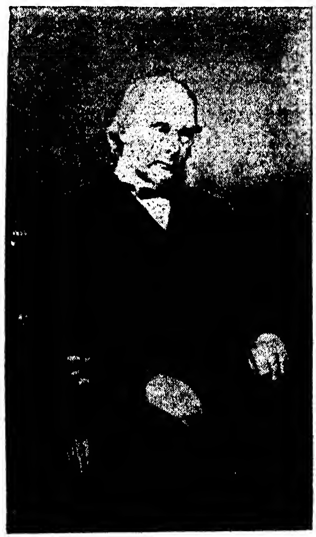


FIG. 7. LISTER

the healthy and vigorous suffering equally with the weak and infirm. Then one day in 1865 he happened to read Pasteur's paper on "Researches in Putrefaction", and a new light dawned. If these germs of Pasteur's were responsible for the putrefaction of *dead* organic material why might they not be the cause of similar changes in *living* tissues, damaged by accidents or the hand of the surgeon, or surrounded by effusions of blood? Germs were universally present in the air, so Pasteur declared, but could be excluded by filtration through cotton wool, or killed by heat and various chemicals: it would be worth trying.

The main essential was to find a vaporizable fluid sufficiently active to kill the germs in the wound and surrounding air, and at the same time do no damage to the wound, or interfere with its natural healing and repair.

An immense amount of time and ingenuity was spent on this search, and eventually Lister chose carbolic acid, which in a crude form was used for the de-odorizing of sewage, and arresting its decomposition. His earlier cases were treated with pure undiluted carbolic acid, but this was found to be unnecessarily strong and damaging to wounds. Eventually a solution of 1-20 or 1-40 was found to be sufficiently effective. The elaboration of the new "antiseptic" method took many years to complete, but its final technique comprised:

1. The performance of operations under a cloud of carbolic spray generated in a steam vaporizer (to kill germs in the air).
2. The disinfection of everything used at the operation, including the hands, by 1-20, 1-40 carbolic acid.
3. The cleaning of the wound with 1-20, 1-40 carbolic, and the application of an elaborate dressing of layers of carbolic gauze and cotton wool, to absorb any discharge, and act as a filter against atmospheric germs.

The almost immediate effect of this method in Lister's hands was a reduction of sepsis and mortality rate, and the healing of many wounds by *primary union* without suppuration. A year or two later he published his results and though their importance could not be denied, his method gave rise to a somewhat acrimonious controversy in the medical profession between those who believed in " Listerism " and those who did not. There were many who did not believe in germs at all ; others who declared that if they were the cause of sepsis simple cleanliness alone was necessary, and antiseptics were harmful as they caused damage to the tissues. The controversy lasted for many years and the fact that there was truth on both sides was only realized early in the present century. Further researches in bacteriology proved that germs and germs alone were the cause of sepsis, and that those existing in the air were of very little importance, hence a large part of Lister's elaborate and cumbersome technique was needless, especially the spray at operations, and the masses of dressings to filter the air. Lister himself had simplified his dressings and discarded the spray early in the 'nineties. Sepsis in a wound, whether accidental or operative, was found to be due chiefly to *direct* infection from any " unsterile " object with which it had come in contact—unavoidable in accident—but in operations to be traced to the skin of the patient, the surgeon's and nurse's hands, or breath, and any instrument, towels, sponges or other appliances.

It was also found that antiseptics like carbolic acid, perchloride of mercury and many others, when used in a strength sufficient to kill germs also harm the vitality and healing powers of the tissues and blood, which in themselves are the best of all antiseptics. Thus arose from the *antiseptic* method of treating wounds the *Aseptic*. This method aims at leaving the healing of the wound to nature,

after it has been cleansed by an unirritating fluid like weak salt solution, and any devitalized tissues removed ; at the same time nothing is brought in contact with the wound that has not been rendered free from germs by sterilization beforehand. The methods employed in effecting sterilization are now one of the most important procedures in the art of surgery and the work of a modern hospital ; and the construction of a modern operating theatre and its appliances are all designed with the same object in view, namely, the use of material which will not harbour dust or germs, and the easy accessibility of everything for cleansing and disinfection.

At an operation, all the towels, gauze, sponges, dressings and instruments are sterilized beforehand by superheated steam at a temperature of 120° C. and are used dry. The surgeon, his assistants, anæsthetist, and nurses are clad in sterilized gowns, caps, and masks covering the mouth and nose, and sterilized rubber gloves are worn on the hands. Nothing must be touched which has not been freed from germs. The most difficult part to deal with is the skin of the patient, and for this various antiseptics are employed, like alcohol, ether, iodine, or picric acid. An important feature of the training of a doctor or nurse is the cultivation of what may be termed a " bacteriological sense ", or the unconscious habit of keeping the hands, instruments or appliances, from touching anything not sterilized.

In the early days of antisepsis, it was almost ludicrous to see how difficult it was for the older surgeons and nurses, earnest converts to Listerism, to acquire this habit. Formerly, a surgeon would often use for his operations one of his old discarded coats, covered with stains, and not infrequently kept for the purpose in the cupboard of the operating theatre ; he might or might not wash his hands between operations, he certainly did not change his coat. When he adopted Lister's methods, he would most con-

scientiously operate under a carbolic spray, and use a lotion for his instruments and hands, and then in a moment of forgetfulness pass his hands through his hair, or, as I once saw, hold an instrument in his mouth! The conveyance of infection by the hands of the doctors

FIG. 8. AN ABDOMINAL OPERATION UNDER MODERN CONDITIONS

(Reproduced by the courtesy of the Clarendon Press from *A Short History of Medicine* by Professor Charles Singer)

or nurses was undoubtedly the chief cause of sepsis in former times, and the introduction of rubber gloves, easily sterilized, has been the most important advance in securing asepsis. Before the introduction of gloves, owing to the difficulty of rendering the naked hand completely sterile, one of our ablest surgeons and pioneers of aseptic

surgery,[1] was accustomed at an operation to have snippets of skin removed from his own and his dresser's fingers, and cultivated for germs, and woe betide the unfortunate owner of a snippet if any growth occurred, and the wound failed to heal without suppuration! It has taken more than fifty years of careful experiment, and the trial of many methods before the present day perfection of technique in conducting operations has been arrived at. Elaborate as they are in detail, including the preparation of the patient, the wholesale sterilization by heat or antiseptics of everything that will come into contact with the area of the operation, the toilet of doctors and nurses, and the after-treatment of the wound, whether accidental or operative—all these precautions are designed to keep away infection by germs, and give the natural healing powers of the body a chance without interference. A *clean* operation, that is to say one where there is no pre-existing inflammation or injury to the part, is expected to result in complete and almost painless healing within a few days as a matter of routine, and suppuration in such a case is considered as a disgrace or disaster due to some avoidable error.

The incredulity with which Lister's antiseptic system was received, and the opposition it met with in England and especially in London did not extend to foreign countries. He was acclaimed in France, Germany, Denmark and Austria, and many of their surgeons came to Glasgow and Edinburgh to study his methods. In 1877 Lister and his advocates thought that his system would be furthered and prejudice allayed if he came to London, and he was offered and accepted the post of Surgeon to King's College Hospital. His calm unruffled manner, kindliness, and sincerity, and the entire absence of any self-seeking in his character at once won for him numerous

[1] Charles Barrett Lockwood.

friends; the results in his wards began to convert the most incredulous, and his students who worshipped him, as they became qualified doctors, spread his doctrines far and wide.

By 1881, when a great International Medical Congress was held in London, Lister's methods had been almost universally adopted by the younger generation of surgeons, and the enthusiasm aroused by the presence of Pasteur, who saw in Lister's adaptations to Surgery the strongest confirmation of his own "Germ Theory of Disease", was a further stimulus to the new system. These two great Masters, each anxious to give credit to the other, met again at the tercentenary of the University of Edinburgh in 1884; and, as related in the last chapter, at Pasteur's Jubilee in Paris in 1892. It can seldom or never have happened before, that two such great benefactors of humanity, each of whose work was complementary to the other, were thus enabled to clasp hands at an International Meeting, and its symbolical implication was not lost on the great audience which had gathered together to "praise famous men", in a cause which acknowledges no boundaries.

It was Lister's great reward to see his Antiseptic System and its further development in the Aseptic System established during his lifetime. He was looked upon in his later years as the "Grand Old Man" of Surgery, and honours fell thick upon him. He was created baronet in 1883, and President of the Royal Society in 1895, and was the first medical man to be raised to the peerage (1903). Later he was awarded the Order of Merit. He died in 1912, and will always be remembered as one of the outstanding figures in Medical History.

Before leaving the subject of the Antiseptic System attention must be drawn to the fact, which will be emphasized still further in later chapters dealing with germ

infections generally, that its essence consists in *Prevention* of sepsis. The treatment of septic infection from a wound, operative or accidental, *after* it has become established and reached the circulation and body tissues is a very different matter, and the use of antiseptics is of comparatively little value. No better instance can be found of the truth of the old adage, " Prevention is better than Cure."

Chapter VIII

ASEPSIS

Further Developments in the present Century, including War Surgery

To one whose surgical career began in the 'eighties in the days of Listerism, and who has lived through the development of the antiseptic into the aseptic system, the still further advances made during this century, as the result of improved surgical technique, and of experience gained in the treatment of war wounds are of absorbing interest.

And, firstly, it may be said in regard to " clean " operations, undertaken by surgeons for the repair of organs, removal of growths, or other procedures in the ordinary run of operation work, it is difficult to see how better results can be expected than have already been attained, by the wellnigh perfect technique of the modern aseptic methods. Primary healing of surgical wounds, however extensive, follows now almost as a matter of certainty. The skull, the chest, the abdomen, the joints, can now be opened to deal with their various distresses, with the certainty that any failure will not be due to subsequent septic infections. Untoward results may happen from shock, heart failure, exhaustion, or incidental complications ; an error of diagnosis ; or some lack of skill in the surgeon himself dependent on the human element, factors which can never be eliminated.

No such certainty has so far been obtained in the surgery of *accidental* wounds of civil life, or in war wounds, where infection at the time of infliction is almost a matter of course.

The question here is, "How can this risk of infection be dealt with in all wounds other than those made in a clean field by the surgeon at a designed operation?"

Until this risk can be done away with it is generally impossible in wounds of any size or depth to at once make a complete repair of the injured tissues and close the gap, or expect with certainty a rapid painless healing, and restoration of function. It is by the evolvement of new methods of surgical technique in the light of experience gained in the Great War, 1914–18, and in the present war, and by new weapons placed in our hands by chemical science that success in this direction now appears to be within our grasp.

In the War of 1914–18, there were three main difficulties to be overcome in dealing with wounds, practically all of which were infected from the outset, through the skin, clothing, missiles or soil; many of the wounded had been lying in the open for hours or days before aid could be rendered, and were suffering from shock, exhaustion, and loss of blood.

They were ripe soil for the development of tetanus, or sepsis from staphylococci, or the more deadly streptococcus, and above all the dreaded gas gangrene, which in a few hours may spread rapidly, converting the muscles and tissues into a sodden mass of putrefying flesh distended with stinking gases.

The danger of tetanus was banished by the injection of antitoxin for every wound, however slight.

It was soon found that the ordinary first-aid routine at dressing stations and other surgical units behind the front lines failed in their purpose as far as regards prevention of subsequent sepsis; the wounded arrived at the base hospitals with sepsis well established, abscesses, and not infrequently general blood poisoning. It was realized that full operative treatment in well-equipped hospitals

within 12–24 hours of the infliction of a wound, and before sepsis had been established was of primary importance. Through the advice of Sir Anthony Bowlby (St Bartholomew's) and Sir G. Makins (St Thomas's Hospital), Consulting Surgeons to H.M. Forces in France, "Mobile Casualty Clearing Stations", equipped for every operative necessity, were established within easy reach of the battle-front.

To these, after first aid, the wounded were brought by ambulance ; they were resuscitated by warmth, or blood transfusion, and then a complete operation was performed to clean the wound and remove missiles, and dead tissues. Within 24 hours, they were sent to a base hospital in well-equipped hospital trains for any further procedures that might be necessary.

These measures led to a vast improvement in the incidence of sepsis, and the prolonged suppuration and pain and misery of an exhausting illness. Nor must mention be omitted of the introduction of the Thomas Splint for fractured limbs. With this appliance fractures could be put in good position, with perfect rest, and safety in travelling.

In spite of these improvements, sepsis and suppuration were not yet conquered ; it was not possible to feel sure that however carefully a wound had been surgically treated by operation, some lurking germ might not be concealed in its recesses—and so matters rested until the Spanish War, 1937–9, when a new surgical enterprise came into being.

The new technique was based on the principle that insufficient regard had been paid to the natural resources of the blood and tissues in combating any infection which might arise after a wound had been thoroughly cleaned and cleared by operation "débridement" Once this had been performed, the wound should be closed at once,

with drainage if necessary, and put at *absolute* rest and left to Nature by encasement in a close-fitting plaster of Paris mould.

Unless serious symptoms arose the plaster case should not be removed for a period of 1–3 weeks, even if it became soaked with evil-smelling discharges. The antitoxins and corpuscles of the blood would be a sufficient safeguard against dangerous germs, and putrefying bacteria were of minor importance.

This method had already been initiated in England by Winnett Orr, but was elaborated apparently with very successful results, in the Spanish War by Trueta of Barcelona, who laid down guiding principles to ensure safety and success, and this new departure has been widely adopted by many surgeons in all parts of the world, though still regarded by others with some suspicion. Surprising as it may seem, when the casing enclosing a "cleaned" wound is eventually removed any raw surface still remaining is generally found to be covered with healthy granulations, and it can be either closed, or skin grafted or left to heal by natural repair.

At the beginning of the present war the marvellous powers of the Sulphonamides [1] (see Chapter XIII), in controlling many infections, chief among which are the coccus germs Staphylococcus, Streptococcus, Gonococcus, gave further impetus to the fight against Sepsis.

The most recent phase in the campaign against sepsis and suppuration of accidental or war wounds is the introduction of the now celebrated Penicillin (see Chapter XIII, Chemotherapy).

An elaborate investigation of the results obtained in Tunisia and Sicily in the summer of 1943 by Professor

[1] The Sulphonamides can be used locally as a dusting powder, or in lotion, or by mouth or injections in generalized infection. They appear to inhibit the growth of germs rather than kill them outright like disinfectants.

Florey of Oxford and a team of surgical experts holds out a prospect that a means has been found of controlling the dangers of infection of wounds if they can be treated early, or even up to fourteen days from their infliction, by means of penicillin.

In addition to local treatment penicillin has a powerful effect in controlling both local and general infections when injected into the body and is used freely by this route (if obtainable) in the graver cases.

Penicillin appears to have no poisoning or deleterious effects on the system, and can even be used to irrigate wounds of the brain. Of twenty-three cases so treated there were only three deaths. Lieutenant-Colonel Jeffrey, who conducted a large number of these investigations, has stated " with penicillin the obstacle of infection has been practically overcome ", and the War Office Report on these researches concludes with the remark, " There can be little doubt that the prevention of infection with pyæmic (pus-producing) cocci, or its control in war wounds, is within reach, and no criticism with its emphasis on difficulties should be allowed to stand in the way of the attainment of this ideal."

Plastic Surgery

Any account of the advances of late years in surgical art, directly due to asepsis and a highly skilled technique, would be incomplete without reference to the astonishing developments of plastic surgery made possible by the work of Sir Harold Gillies and others in this particular field.

The horrible disfigurements of features in face wounds and the huge unsightly scars, and loss of substance in those of the body or limbs—disfigurements which were the source of the greatest mental distress to patients and friends —can now in large part be remedied by plastic surgery.

Features are remodelled and gaps closed by living skin flaps still partially attached to an accessible limb and brought up to the area of disfigurement, or by direct skin grafting.

New noses, or eyelids, or lips, are thus fashioned and go far to lessen the horrible deformities left by accidents or war injuries.

The highest developments in the arts or crafts with inanimate materials seem less wonderful than the artistry and delicacy which make possible these results of plastic surgery on living tissues in the hands of Master Craftsmen.

And all their labour and skill would be wrecked and ruined by infection from any neglect of the strictest asepsis.

From Lister's 1-20 carbolic to penicillin! What a record of vicissitudes the Antiseptic system has undergone in the last seventy or more years in the endeavour to attain the object at which Lister aimed—a means by which wounds of all descriptions could be freed from infection by microbes, healing obtained by primary union, and the risks of suppuration or general blood poisoning overcome. Each decade has witnessed further advances, the saving of more lives, the relief of more suffering. The Antiseptic fades gradually into the Aseptic system, by means of which, together with improved surgical technique, the goal has already been reached as regards the designed operations of surgery with a "clean field", but not yet fully attained in wounds already infected in the accidents of civil life, or the injuries of war. Chemistry again has come to the rescue and with the introduction of the Sulphonamides—derivation of a dye—and penicillin manufactured by a mould, high hopes are entertained that Lister's full object will be attained, and that by his original adaptation of Pasteur's researches to the needs of Mankind his genius will be fully crowned by success.

CHAPTER IX

BACTERIOLOGY

Nature of Germs

IN the two preceding chapters we have discussed the discoveries of Pasteur and Lister, and it now remains to trace the further developments of the " Germ Theory ", and see what light Bacteriology has thrown on the nature of Germs, how they cause disease, and how they can be combated.

But, first of all, what *are* germs, microbes, micro-organisms, or bacteria, as they are variously called as a class, with their subdivisions into (according to their form and mode of growth), " bacilli " and different varieties of " cocci " ?

Germs are the smallest forms of life. Many of them are so small that, after special staining processes, they have to be magnified a thousand times or more under the highest powers of the microscope before they become visible. And there are some still smaller that have never been seen, which can pass through the most exacting of filters, and are known as " filter passers " ; we know they exist from their effects, and because they can multiply—that is all. To imagine this smallness is difficult. Imagine an enormous giant whose sight was such that the smallest object he could see with the naked eye was the size of St Paul's Cathedral. The average size germ in his world would be about the size of an orange ! They exist almost everywhere, in the air, in water, in the earth, and in the bodies of animals and plants in countless millions, and form a great invisible world in and around us. They can multiply by simple division or by forming spores, and

under favourable conditions with such astonishing rapidity, that millions are reproduced from a single germ within a few hours.

As Pasteur discovered, it is through their agency in the economy of Nature that the complex cells of dead organic matter, whether animal or vegetable, are split up by the processes of decomposition, putrefaction, or decay, into the simpler form of water and gases and a mineral residue, elements from which in turn animals and plants have themselves been built up. Were it not so, the world would be choked by the unchanging masses of dead animals and plants. In addition, germs are the chief agents in the vast variety of fermentations, many of which we turn to our use, and in the fertilization of the soil, by their power to liberate nitrogen and make it available for building up plant life.

It is evident, therefore, that they play a very beneficent part in Nature, and that we could not get on without them, but from our point of view, alas, some of them are naturally evil, or at some remote period acquired the evil habit of attacking *living* instead of dead plants and animals, and became the cause of many of the diseases from which they suffer. A desire for a change of diet may have been the first motive, as it was with our Mother Eve at the Fall ; or with the wild parrots of New Zealand, which of late years have taken to killing sheep to get at the fat in preference to their natural diet of fruit.

How Germs Attack Us

Disease-producing germs might, of course, argue that they too play a beneficent part by acting as a check on over-population, but so far-reaching a view would hardly carry conviction to one who has been smitten with the Plague.

However this may be, the fact remains that these evil germs can cause disease or death by destroying the delicate cells of which the different tissues of plants and animals are composed. Often they exercise a nice discrimination in the choice of the particular organ for which they have a preference; the blood itself perhaps, the nerve cells of the brain and spinal cord, the lungs, or bowels, or even the tough skin. Nor is one variety of germ responsible in most infections: one begins the work, and succeeding phases of the malady are caused by others who seize the chance of altered conditions and weakened resistance to make their presence known; so that we often get a *mixed* infection, and with it a complication of the symptoms.

An illness which begins for instance as Pneumonia, or Scarlet Fever, or Typhoid, merges into a general blood poisoning caused by a different germ. A germ having gained entrance to the particular part of the body which it affects may multiply with amazing rapidity: the infection may remain local causing a limited inflammation of the part as in a boil, or a general infection of the body, conveyed through the blood or lymph channels, may take place as in blood poisoning (septicæmia) or Scarlet Fever.

It is not only the germs themselves in their millions which cause trouble by blocking blood vessels and choking the tissues; but more deadly still they secrete poisons (toxins) which paralyse and break up the blood cells as well as the cells of the organs or structure which they attack.

How has all this been found out? It is due to the Science of Bacteriology which arose from the work of Pasteur and Lister, and was carried on by many able workers in all parts of the world, who devoted their lives to research and the intimate study of these minute organisms.

It is impossible to convey in a brief survey the exacti-

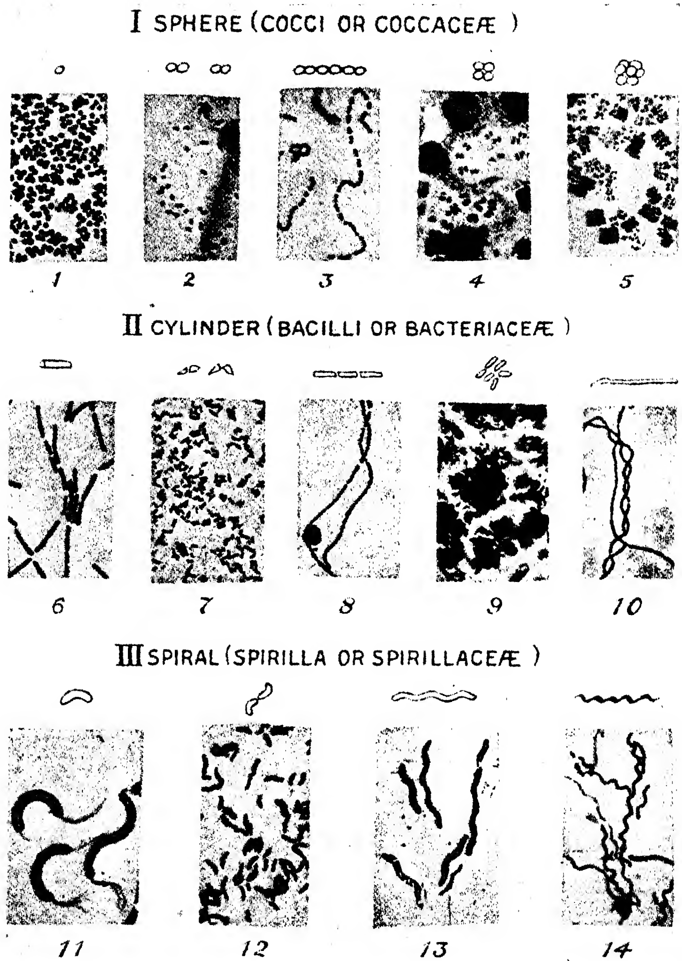


FIG. 9. TYPES OF BACTERIA

From Park and Williams' *Pathogenic Micro-organisms*. (Reproduced by the courtesy of Messrs Baillière, Tindall & Cox)

EXPLANATION OF PLATE

FIG. 1. Single cocci. Staphylococcus (abscess) × 1000

FIG. 2. Cocci in twos. Diplococcus (pneumonia) × 1000

FIG. 3. Cocci in chains. Streptococcus (blood poisoning) × 1000

FIG. 4. Cocci in fours. Tetragenus (a secondary invader) × 1000

FIG. 5. Cocci in packets. Sarcina lutea (in air) × 1000

FIG. 6. Single bacilli long. Hay bacillus × 1000

FIG. 7. Single bacilli short. Hoffmann bacillus (a diphtheroid) × 800

FIG. 8. Bacilli in chains. Anthrax (from spleen of mouse) × 500

FIG. 9. Bacilli in bunches. Typhoid × 500

FIG. 10. Bacilli in threads. Anthrax (from blood of frog)

FIG. 11. Spirillum undula, showing flagella × 1000

FIG. 12. Spirillum cholera × 1000

FIG. 13. Large spirillum, from water × 1000

FIG. 14. Small spirillum (rubra) × 1000

tude, ingenuity, and immense labour involved in the elaboration of the methods by which it has been found possible to isolate one germ from hundreds of others ; to cultivate it pure in successive generations ; to find out the food (media) solid or liquid, and the temperature best suited to its growth ; how it is most easily killed, and how reproduced, by division or budding, or spore formation.

To a layman looking down a microscope these germs, stained in aniline dyes, look very much alike—dots or dashes—but each has its particular " cultural " characteristics by which it can be identified. Some of the disease germs form poisons (toxins) in the artificial media (like beef broth) in which they grow, and after filtration or sterilization the poisons can be used for experiment in different strengths, as will be explained later in the preparation of vaccines.

How is it possible to identify a particular germ as the cause of a disease ?

1. It must be found constantly in the blood or the part affected during life, or immediately after death.
2. It must be separated from other germs, and grown in pure culture on artificial media like meat jelly, or blood serum ; which are then kept at a constant temperature in incubators.
3. Preparations made from the pure cultures—which consist only of the particular organism under trial—must be capable of reproducing the disease when inoculated into human beings or animals, and be recoverable from them as in the first instance.

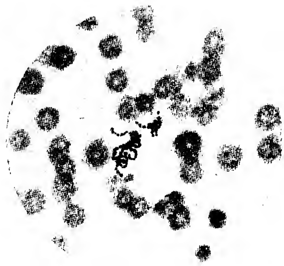
During the last fifty years the particular germs responsible for a large number of infections and other diseases have been identified by these tests, and this knowledge has led to equally scientific methods for their prevention or treatment. When once the germ has been " spotted ",

it may be possible to find out its life history, how it lives, how it gains access to our bodies, how it can be destroyed or weakened, and knowing these we can employ our best weapon, *prevention.*

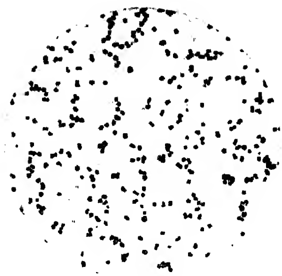
Foremost among those who have made these discoveries, and elaborated new methods of cultivating germs, and studying their life processes, must be placed the great German bacteriologist, Koch, who in 1882–3 identified the tubercle bacillus, and the germ of cholera. The following list of some human diseases (which does not include a number of the less important, or those limited to the Tropics), in which the specific germ has been found, with the date and the name of the discoverer will give some idea of the importance of these researches : [1]

1875	Amœba of Dysentery	Losh
1875	Germs which infect wounds	Koch
1871–9	Leprosy bacillus	Hansen
1880	Blood poisoning germs	Pasteur
1880	Typhoid bacillus	Eberth
1880	Malaria parasite	Laveran
1882	Tubercle bacillus	Koch
1883	Cholera germs	Koch
1883	Diphtheria bacillus	Klebs and Löffler
1884	Tetanus (lockjaw) bacillus	Nicolaier
1887	Meningococcus	Weichselbaum
1887	Malta Fever	Bruce
1894	Plague bacillus	Kitasato and Yersin
1897	Dysentery bacillus	Shiga and Flexner
1901	Sleeping sickness	Castellani and Bruce
1905	Syphilis	Schaudinn

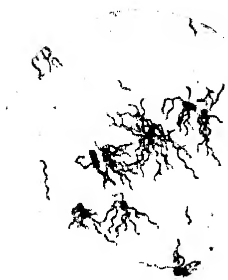
[1] Wyndham Lloyd. *A Hundred Years of Medicine*, p. 326.



a. Streptococcus in blood × 1000 (Scarlet Fever)

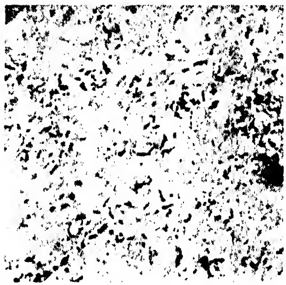


b. Meningococcus × 1000 (Cerebrospinal Fever)



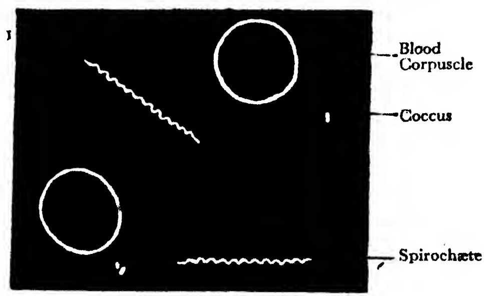
c. Typhoid Fever Germ × 1000

(*a, b, c,* By courtesy of Professor Mervyn Gordon, F.R.S.)



d. Tubercle bacillus in lung × 1000

(By courtesy of K.E.F.)



e. Syphilis Germ, " Spirochæta Pallida, Blood Corpuscle, and Cocci "

(From Singer's *Short History of Medicine,* by courtesy of Dr. Singer and Clarendon Press)

FIG. 10 *a, b, c, d, e.* DISEASE GERMS

A brief account must now be given of how germs attack us, and how our bodies, aided by Science, are able to defeat them.

In the first place how do they gain an entrance? This may happen as regards the skin, through a wound, or prick, or crack, or even an insect bite, for the surface and superficial layers harbour a large variety of germs, some of which may cause suppuration or sepsis. They may be drawn in with the air and gain entrance to the membranes of the nose, throat, bronchial tubes or lungs, or swallowed with food or drink and affect some part of the digestive tract. The skin and membranes are an effectual barrier when sound, but not so when damaged by injury, or unhealthy from any cause.

After gaining entrance to the particular part of the body, suitable for its development, and after an incubation period, the fight begins. With intense rapidity the germ attacks the body cells, and their blood supply, and, multiplying enormously, endeavours to penetrate farther into the invaded territory. Its chief weapon is a poison or toxin which can destroy or paralyze the delicate tissues, or the blood corpuscles and fluid which supply them with oxygen and nourishment. The fight may be confined to the part invaded, causing what we call a *local inflammation*, e.g. a boil, or—as generally happens, in addition to the local disturbance, the germs or their poisons enter the circulation and cause a *general infection*, which is manifested as a rule by a rise of blood temperature, or fever, and a feeling of illness such as headache or lassitude.

The seriousness of such a general infection necessarily depends on the character of the particular germ and the disease to which it gives rise, and the fitness of the body to defend itself.

The most dangerous are those which attack and destroy

the blood itself, or the delicate nerve cells of the brain and spinal cord which regulate the functions of all the organs, and more especially the heart and lungs. The weapon of the germ is its poison, and we must now consider the means of defence by which it can be countered.

How the Body Attacks Germs

Firstly, what we call *inflammation* of a part is not an illness in itself; it is a defensive action of the body at the spot where a germ is beginning its attack. Secondly, a *fever* is not a general illness; it is a defensive reaction of the body to counteract the germs or their poisons

FIG. 11. A WHITE CELL EATING GERMS, FROM THE NASAL SECRETION IN INFLUENZA × 1000

(By courtesy of Professor Mervyn Gordon, F.R.S.)

FIG. 12. STAPHYLOCOCCUS (CULTURE), CAUSE OF BOILS, INFLAMMATIONS, BLOOD POISONING

(By courtesy of K.E.F.)

which are invading the whole system, by speeding up the circulation and accelerating the functions performed by the different organs. Circulating in the blood with the red cells which bring oxygen from the lungs to the tissues, there are also large numbers and several varieties of *white* cells,[1] not unlike that minute jelly-like creature

[1] *Leucocytes.*

found in water, an Amœba, which exists as a single cell, capable of independent motion, digesting food, and multiplying its kind by simple division.

These white blood cells, formed in the spleen, and the bone marrow, and the lymph glands, find their way into the blood. Here, among other useful purposes not yet fully understood, certain of them act as defenders against microbes ; they are the infantry of the line. If one of them meets with a foreign germ it proceeds to surround it with a jelly-like arm, takes it inside and digests it. Biologists call them *phagocytes*, which means—*cells which eat.*

In addition to these cells which form the first line of defence, the body is capable of manufacturing in its blood or other cells an antidote or *antitoxin* to the particular poison secreted by any attacking germ, and this too is poured into the fluid part of the blood and serves to neutralize the poison, which is being carried to distant parts. The antidote may be compared to the chemicals in a mask used in gas warfare.

The Battle of the Boil

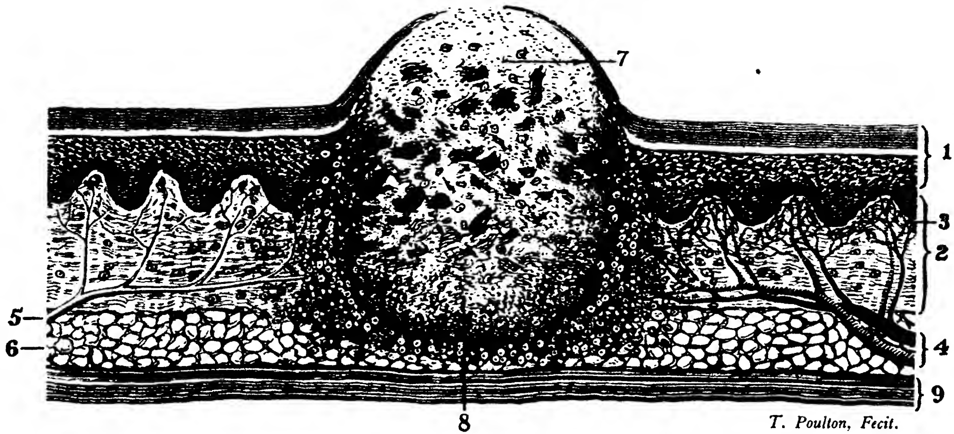
It is quite easy to imagine a local inflammation as a skirmish on the frontier, and the accompanying fever as a general mobilization of all the resources of the country to repel an invader. An example of what happens in a common form of inflammation like a boil illustrates what occurs in many other infections.

Under the microscope the germs which cause a boil look like tiny round dots, grouped together into clusters. They may be found on the surface of the skin, or at the entrances to the sweat and grease glands which lubricate it. The skin gets a slight injury—like a crack, or perhaps a rub from a stiff collar—and some of these little

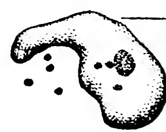
cocci as they are called get into the deeper layers of the skin or penetrate the lining of its glands. Here they find a rich soil for their development, and a suitable temperature, and soon multiply into millions, living on the blood cells and fluids, and the framework of the tissues under the skin, which they paralyse and break up with the poison they secrete.

But the body does not remain inactive under the invasion, which acts as an irritant to the sensory nerves and their terminations. These, like Post Offices and telephone wires, connect all parts with District Centres, and Headquarters. Messages are sent to the Nerve Centres in the Brain and Spinal Cord which regulate the body temperature, the varying size of the blood vessels, and the blood supply to any region which requires help. The message is recognized as a pain, or discomfort. The warning notices of the invasion meet with an immediate response. Headquarters at once gets busy; according to the danger anticipated, a general or partial mobilization of the resources of the body takes place. Storm troops and reserves, in the shape of the white blood cells in their thousands, are despatched along the great arterial roads, which are capable of immediate expansion, and designed like the railways for up and down traffic; arteries from, veins to, the heart. The white cells reinforce the local guards already on the spot, and the circulation brings an ever increasing supply of oxygen carried by the corps of red blood cells, as well as food, in the fluid parts of the blood. The battlefield itself and the surrounding neighbourhood become congested and swollen with combatants and supplies; the up roads are barred to prevent the *cocci* penetrating to important centres, and the few that get through are killed in hand to hand conflict with the whites. The centre of the fight is shut off by surrounding masses of

FIG. 13. *Diagram* "BATTLE OF THE BOIL"



1. Epidermis (Scarf Skin)
2. Dermis (True Skin with papillæ)
3. Capillary vessels
4. Small artery and vein
5. Nerve with branches
6. Fat Cells
7. Pus in boil (dead tissue, blood cells, germs, blood fluids)
8. Barrier of live white cells (phagocytes)
9. Fascia (fibre)



defenders who dig themselves in, forming as it were trench after trench and heaped up barricades to limit the invasion. These solid barricades form the hard, swollen, tender area surrounding the centre of the boil.

It is possible that, as with aeroplanes carrying gas bombs, some of the poisons secreted by the *cocci* may be carried into the interior and cause disturbance, but they are easily disposed of by the antidotes or by the "anti-bodies", manufactured in the body factories by skilled cells, which, like our chemists, seem to be able, if given a little time, to provide an antidote for the newest death-dealing chemicals. In a boil no *general* mobilization in the shape of a rise of temperature is necessary as a rule, and the local disturbance is not regarded as serious by the authorities at headquarters.

Meanwhile what is happening in the centre of the battle? Here white cell meets *coccus*, and one or other gets killed. So numerous are the enemy that the fight seems to favour their side, and the focus or core of the conflict is piled with the corpses of the white cells, and the ruins of the structures they were defending, floating in the tainted fluids of altered blood. This collection of the débris of battle is known as "pus" or "matter", and the battlefield we call an abscess.

And what will be the result? Shut in on all sides by impassable barriers, the cocci, even if victorious in the centre, die from want of fresh food, or choked by their own numbers, and the bodies of the slain. Gradually the barriers are removed and the inflammation disappears, leaving no trace of its occurrence. The remains of the conflict are carried away by the circulation, and eaten up or destroyed by the blood cells. Such a case would constitute a "blind" boil. Sometimes on the other hand the pressure in the centre of the field becomes so great, that the pus, unable to pass the hard

defences which surround it, bursts through the stretched skin, and discharges itself; or the surgeon relieves it by a timely cut. This at once gets rid of the main body of the enemy in the centre, and now there are left only those engaged on the sides of the entrenchments. These are soon killed by the swarms of defenders who man the defence works, reinforced by fresh supplies which are hurried along the now less congested roads. The nerves cease sending their constant messages of pain, and the body resumes its humdrum life. The only trace of the invasion left behind may be a small scar where repair cannot entirely restore the original structure of the mosaic cells of the skin, or the down which grows on it—much as the chalk uplands of the Somme, though Nature has again covered them with verdure, still remain scarred with the traces of mighty shell holes and bared surfaces, witnesses of an analogous struggle on a gigantic scale.

The same variety of germ (*Staphylococcus*) which causes only a " boil " in the tough structures of the skin may be the cause of a much more serious illness if it gains entrance to the blood stream and attacks internal organs. It may cause a tonsillitis—or quinsy, or abscesses in any part of the body, or even invade the bone marrow itself, one of the great depôts of the defending white blood cells.

A General Invasion

And this leads to the consideration of what happens when a *general* infection of the body takes place, with or without a local disturbance or inflammation at the place of entry.

General infection occurs in all the common infectious diseases such as Measles, Scarlet Fever, Mumps, as well as in the more dangerous ones like Pneumonia, Typhoid Fever, and Tuberculosis. Here the germ responsible

penetrates through the more delicate lining of the air passages, or bowels, and after an " incubation " period, during which it is multiplying and preparing its forces (often with very little local disturbance), it invades the general system itself, or from its points of vantage launches its poison into the circulation or the lymph channels.

In these circumstances the picture is very different from that of a boil.

An attack of Measles may be taken as an example. The enemy here is much more crafty than the boil-staphylococcus. To begin with it is a " filter passer " and so small that it has not yet been identified with certainty. When it invades, it settles probably on some spot in the air passages, nose, throat, or windpipe, and makes so little disturbance in the incubation period that the defending powers put it down to a mere raid by some unpleasant neighbours, the common cold or catarrh people, who are always making trouble. Accordingly only a local mobilization is made, with perhaps a slight raising of the body temperature, and all seems well. Then suddenly with its secretly multiplied forces the general invasion bursts forth all over the body, before adequate preparations can be made by the defensive white cells, or the manufacture of antitoxins in the blood begun. Possibly there may be a certain amount of this material available in store which has been handed down by our parents. The sudden onrush of germs, or poison, or both, upsets all the workings of the body ; the head aches, the muscles become weak, the secretions and digestive juices are dried up, and on the skin appears a rash where poison or germs are collecting in the network of canals which nourish it. And what are the defensive powers doing ? Although taken by surprise, they respond at once, and with almost unnecessary vigour. The lungs are ordered to work more quickly in order to supply

more oxygen to feed the furnaces and supply the red blood cells. The heart is ordered to beat more frequently and pump more vigorously ; the blood channels to widen up to meet the increased flow, the cells which make " antitoxins " to work their hardest, and the white cells to issue from their barracks ; the stomach and bowels to take in more fluid to replace the losses. Everything is set at a higher pitch of energy, as may be gauged by the high degree to which the body temperature is raised. So great is the disturbance caused by the general mobilization, and the concentration of the blood in the important industrial centres, that the outlying parts like the skin actually *feel* cold, and the body shakes and shivers with the efforts it is putting forth, in what is called a *rigor*.

And how will this general invasion end ? Each infection runs its special course, but as a rule it may be said that the body will conquer if it possesses already, or can manufacture in time, sufficient " antitoxins " to neutralize the toxins or poisons, and keep up the supply of blood cells to combat the germs themselves. The germs may also cease to multiply, or die off naturally, if the special food they live on is used up. Thus many infections run for a limited period and then suddenly, or gradually, come to an end. But there is another side to the picture. The body may not be able to keep up its powers of resistance ; or may even fail to respond at the onset and is then overwhelmed before it can do anything. The important nerve centres become poisoned, and the heart falters, and all the functions are slowed down. Other varieties of germs may then attack the weakened tissues like scavengers on a battlefield, and the end is not then long delayed.

Recovery and Immunity

If all goes well, the body recovers and builds up its resources again after a longer or shorter " convalescence ", and generally no visible signs are left of the invasion, unless some organ or limb has been permanently injured. The heart for instance may remain damaged after an attack of rheumatic fever ; or a limb remain paralysed after damage done to its nerve centres in the brain or spinal cord.

But even if there are no visible signs left after a general infection, we are not quite the same as before ; some change has taken place in the body as a relic of the attack, and this change may last for months, or years, or for the rest of life according to the nature of the illness. Something has been left behind in the shape of a mysterious power which the system now possesses, of being able to resist a second invasion by the same variety of germ, possibly due to presence of antitoxins. This happens for life in some infections like measles, chicken-pox, mumps, or small-pox, and to a more limited extent in influenza, typhoid, and many others, and is known as *Immunity.*

Antibodies

Of late years the study of Immunity has been one of the chief concerns of a new Science—Biochemistry—which deals with the intimate nature of living matter and its various products. The subject is far too technical and abstruse for detailed explanation here, but as far as is known at present Immunity is conferred by definite substances which have been manufactured by the blood cells or body tissues as the result of an infection, and which remain in the blood after an attack for a varying

period. They are known as "Antibodies", but their composition has not yet been ascertained, and they can only be recognized by their effects. There are various classes of antibodies, known as (1) Agglutinins, which coagulate germs. (2) Lysins, which dissolve germs. (3) Antitoxins, which neutralize the poison of the germ. (4) Opsonins, which help the blood cells to digest germs —(acting perhaps like a cocktail). A good example is the blood test used in the diagnosis of typhoid fever.[1] A drop of solution containing thousands of living typhoid bacilli is placed on each of two slides under the microscope. To No. 1 is added a drop of clear serum[2] from the blood of a normal healthy person who has not suffered from the complaint. To No. 2 is added a similar drop from the serum of a patient in the middle or soon after an attack. In the case of No. 1 the bacilli, which are motile, continue their activities as before and can be grown again in culture. In the case of No. 2, after a few minutes the bacilli become motionless, and become incapable of culture. This beautiful experiment clearly shows the presence in the blood of a typhoid patient of some "antibody" or "agglutinating agent", which is being produced as a defence against the germs and the poison they contain.

An antibody is "specific", i.e. can only protect against the particular infection which has induced its formation, not against others.

Presumably we are born with a number of antibodies already in our systems, inherited from our parents, otherwise we should be catching one infection after another. As it is we never suffer from some of them. To these we are said to have a *Natural Inherited Immunity*. Or if

[1] Widal reaction.

[2] Serum is the clear fluid which remains after clotting of blood : or the removal of the red cells in a centrifugal machine.

we are liable, and suffer from an attack, we gain thereafter for a longer or shorter period a *Natural Acquired Immunity* against that particular complaint. It is easy to see how these considerations account for the *periodic* visitations of epidemics, and their varying degrees of severity according as they fall on a community lacking or with only partial immunity. Scarlet fever for instance is of a much milder type nowadays than it was in the last century on account of the present generation having inherited a greater power of resistance from their parents who stored up antibodies. On the other hand, in the year 1871 an epidemic of Measles occurred at Fiji in the Pacific, where previously it had been unknown. The natives were virgin soil, and it swept away a quarter of the whole population.

So too the aboriginal races of Australia are gradually being wiped out by Tubercle, a new introduction by the white settlers ; whereas all white races have acquired varying degrees of inherited protection, which, together with preventive measures, is reducing its incidence and mortality rate.

Now all this long account about germs, and how they attack, and how the body resists and generally wins, may seem tedious and superfluous, but it is necessary if we are to understand clearly modern methods of treatment and the ways in which doctors and hospitals are learning how to defeat disease-producing microbes.

Prevention

Firstly, and by far the most important, comes *Prevention.* Bacteriologists have been able to discover the germs responsible for a great many diseases, and a knowledge of where and how they live outside the body, and how they gain access, enables us to attack them at their source, or prevent their invasion. Previously the source

was unknown or we were looking in the wrong direction. A few examples will suffice for illustration.

Tubercle is not as formerly thought, an inherited disease, but an infection, and the bacilli are conveyed in the air of badly ventilated rooms, in the spittle of patients, in tuberculous meat or milk. Prevention is by open-air treatment, disinfection, isolation, destruction of infected cows, and a pure milk supply.

Typhoid Fever germs are found in contaminated water or milk, in shell fish, and in the excrements of " carriers ", i.e. apparently healthy people who after an attack continue to harbour the germs in their bodies, and may spread the disease by infecting food, milk, etc., or by direct contact. Prevention is by disinfection of all that has been in contact with a patient ; a pure water supply, stopping of sewage contaminating shell fish beds, detection and isolation of dangerous " carriers ", pasteurization of milk.

Diphtheria. The infection does not arise, as we used to think, from " bad drains ", but is often conveyed by direct infection from an established case—an apparently mild sore throat, or nasal catarrh, or again from a " carrier ", who all unwittingly is going about spreading the disease, or infecting milk or other articles of food and drink. Prevention is by examination of throats of all " contacts ", by the detection of " carriers " and by tracing the incidence of the infection to perhaps milk or other articles of consumption.

Numerous other examples could be given, but it is sufficient to say that Preventive Medicine is the most important method for resisting germ infections. Numerous organizations, and the Sanitary Authorities working

under the Ministry of Health with skilled Medical Officers, Bacteriologists, Chemists, and Sanitary Officers, keep watch over all that modern Science has shown may be sources of danger, and as far as possible circumvent them. In some respects knowledge has outstripped the means available, on account of expense, or interference with vested interests, or simple prejudice; otherwise, as has actually happened with Hydrophobia and Typhus, there is no reason why Typhoid, Smallpox, and possibly Tubercle, Diphtheria, and others might not be stamped out by prevention alone. Such possibilities are well within the range of vision.

Vaccines

But what happens when preventive measures fail? Has modern knowledge discovered any methods, apart from drugs and sustaining the bodily strength, which will be of service in the presence of an epidemic, or when the germs or their poisons have once gained an entrance? Under these circumstances modern treatment is directed to the imitation or reinforcement of those methods which Nature itself has evolved in conferring Immunity. In many instances this can be brought about by:

(1) Stimulating the body and blood of the patient, by the injection of a *vaccine*, to manufacture the particular antibody which will counteract the germ or its poison; or by

(2) The introduction into the blood of a serum from another animal or human being *already* immunized against that infection, and whose blood is therefore highly charged with the specific antibodies. This serum contains an *Antitoxin.*

In (1) the patient himself has to manufacture the antibody. In (2) the manufactured article is supplied ready made.

(1) *Vaccines* are employed to induce a very mild form of the infection, with the consequent reaction of the body and production of antibodies—as in ordinary cow-pox vaccination. They are prepared from pure cultures of the appropriate germ by using

(*a*) The living germs, or virus, diluted and weakened, as for Hydrophobia.
(*b*) Dead germs, sterilized by heat or otherwise, as in Typhoid.
(*c*) The toxin or poison only, the germs having been removed by filtration, as in Diphtheria or Tetanus.

In some germs the poison is confined to their actual structure ; in others it is found dissolved in the medium in which they grow, and the particular method adopted depends on these circumstances.

Beginning with the weakest dilutions, inoculations in increasing strengths are made at regular intervals, until the body has fortified itself against a dose which if used at the onset would have caused serious results. The patient is now " immune " for a longer or shorter period against an ordinary infection. The inoculation of the vaccine, given in graduated doses, generally has no ill effect beyond a very temporary indisposition. Vaccines are mostly used as a *protection* against certain infections, which are causing an epidemic, e.g. plague ; or when there is a special risk of infection, e.g. typhoid ; or if susceptibility is known beforehand, e.g. scarlet fever, or diphtheria. We can look forward to a great diminution of the incidence of diphtheria by the practice now generally adopted of testing young children for susceptibility, and immunizing them accordingly with diphtheria *toxin-*

antitoxin. Except in certain cases, vaccines are useless after the illness has started, since considerable time is required for them to take effect, and they are an addition to the poison from which the patient is already suffering.

Examples. In the Boer War, before inoculation of Vaccine for typhoid fever had come into general use, there were over 59,000 cases recorded and 8,227 deaths. On the Western Front during the Great War, there were only 213 deaths from Typhoid, among an average of 1½ million troops engaged. By the end of 1915, the French (who had not employed Anti-typhoid Vaccine) had recorded 96,000 cases and 12,000 deaths; for the same period the British 2,689 cases with 170 deaths.[1]

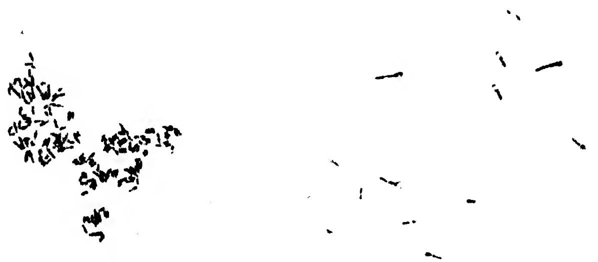
Specific Vaccines have also been prepared from the germs that cause Plague and Dysentery, and are successfully employed to confer immunity, especially in the Far East. Haffkine, who introduced the plague vaccine, tested it on himself, to ascertain its strength and effects before administering it to others.

Antitoxins

(2) Antitoxins are prepared from the blood of animals (e.g. a horse) which are susceptible to the infection, and have been highly immunized previously by repeated injections of increasing strengths of the toxin given as a vaccine. After some weeks or months of preparation their blood becomes charged with "antibodies" and a strength of toxin which far exceeds an ordinary fatal dose can be given without the least effect. One or two pints of blood are then withdrawn from a vein by a hollow needle, and from this, antitoxic serum is prepared, and after its strength has been standardized it is put up in sealed glass containers ready for use. The horse has in

[1] Masters, *Conquest of Disease*, p. 257.

fact been used as a manufactory of antibodies for our service, and will be the means of saving hundreds of lives. While he is doing all this he lives a life of luxury and ease compared with his brothers who toil at the plough, or compete in races for our amusement, or get slaughtered in battle. He hardly notices the little pricks of the needles, and gives up a small quantity of his blood with the same composure as do the gallant volunteers of the Blood Transfusion Service.



a. Diphtheria bacillus × 1000 (By courtesy of Professor Mervyn Gordon, F.R.S.)

b. Tetanus bacillus × 1000 (By courtesy of K.E.F.)

FIG. 14. DISEASE GERMS

Now this ready-made " antitoxic serum " containing the " antibodies " of an infection can be inoculated directly into the blood or tissues of a patient who has caught the complaint, and can make up for any deficiency, or increase the natural resources which may be failing. It is in this way a *direct* remedy, but its success depends greatly on its early administration in the illness, before the poison of the infection has fixed itself in the nerve or blood cells on which the vital functions of the body rest. The free or circulating poisons can be neutralized, the fixed poisons cannot, so that early treatment is essential.

Antitoxins of Diphtheria and Tetanus

The most striking and almost dramatic successes with antitoxin treatment occur in Diphtheria and Tetanus (lockjaw). In Diphtheria its success is almost invariable if given within two or three days of the onset, and it confers immunity for a sufficiently long period to those who have been exposed to the infection. In Tetanus the results have been equally remarkable.

The germ of Tetanus is found in cultivated and manured soils. It dislikes oxygen and gains an access and finds its opportunity in deep and lacerated wounds into which dirt has been carried from the clothing or otherwise. As in Diphtheria, the germ itself remains localized but produces powerful poisons which are absorbed and carried in the blood to the nerve centres in the brain and spinal cord, which they disorganize. In Tetanus this produces a rigid and horribly painful spasm of the muscles, and eventually paralysis of the heart and breathing mechanism. This dreadful disease used to be fatal in about 50 per cent. of those attacked.

The best example of the efficacy of tetanus antitoxin was afforded in the Great War when it was injected as a matter of precaution for all wounds, whether slight or serious, on account of the highly infective nature of the soil. In the whole War there were 2,500 cases of tetanus with only 550 deaths. In August and September 1914 (before its routine use) of every 2,000 wounded 20 developed the disease and 17 died. After its routine use only 2 in 2,000 wounded were attacked, and only 1 in 2,000 wounded died.[1]

If the antitoxin is employed early *after* the onset of the complaint, mortality is reduced from 50 per cent. to 15–20 per cent.

[1] Masters, op. cit., p. 186.

Antitoxins prepared in the same way are used for other infections and given as early as possible after the onset of illness, e.g. in septic poisoning, puerperal fever and pneumonia—but as there are differing strains of microbes, with corresponding antibodies in each of these complaints, the effect is not so certain as in diphtheria and tetanus.

Antitoxin in Measles

Measles has recently been treated by injections of serum obtained from the blood of patients recovering from an attack. If given to "contacts" it will confer immunity for a sufficient period: and given early *after* the onset will ensure a very mild form of the complaint or end it rapidly. The serum of a patient during convalescence is charged with measles antibodies and by allowing a few ounces of his blood to be withdrawn a patient can do a great service to others, with no harmful results to himself.

Recently, too, by the employment of toxins and antitoxins in combination, delicate tests have been discovered whereby it is possible to find out if anyone is naturally immune, or liable, to Diphtheria and Scarlet Fever,[1] and if liable they can be permanently protected by injection of the appropriate serum. This has greatly reduced the incidence of attacks among hospital nurses and others who are constantly exposed to these infections.

Apart from general infectious diseases, the study of germs and their poisons has disclosed the fact that much ill-health, and many chronic complaints, the causes of which were unknown, are due to absorption of microbes or their products from parts of the body where a *local* infection has been set up. This frequently occurs in

[1] "Schick" and Dick tests.

the appendix, or tonsils, or teeth, and the removal of the part affected or its efficient treatment restores the general health, or relieves symptoms which may be appearing in quite different parts of the body like the muscles, or joints, or nerves. or digestive organs.

Chapter X

VIRUSES

The latest researches in bacteriology have been concerned with the investigation of diseases supposed to be caused either by "filter-passing" organisms, or chemical poisons resembling ferments. Their exact nature still remains uncertain, and they are known as viruses.

These elementary bodies have been found in small-pox, vaccinia, influenza, measles, hydrophobia, typhus, yellow fever, poliomyelitis and other human diseases. In animals, Swine influenza, Foot and Mouth disease, Psittacosis of parrots, and others. In plants no less than 140 diseases are probably due to viruses, among the more serious, Potato leaf roll, Tobacco mosaic, Tomato mosaic. They are apparently endowed with life and power of reproduction. Our knowledge of viruses is greatly restricted by the fact that the majority are so small that they cannot be seen by the highest powers of the ordinary microscope using transmitted visible light with a magnification of 1,000–2,000. By using rays of a shorter wavelength than visible light—viz., ultra-violet—these minute bodies can, however, be photographed and made visible, by a camera attachment to the microscope, and they then appear as minute rods or spheres.

A still further advance has lately been made by the introduction of the Electron Microscope, a marvellous instrument which operates without the use of any kind of light ray, but by means of electrons generated at the cathodal terminal of an electric circuit. With this apparatus particles of approximately $\frac{5}{1,000,000}$ of a millimetre can be photographed, and thus we are enabled

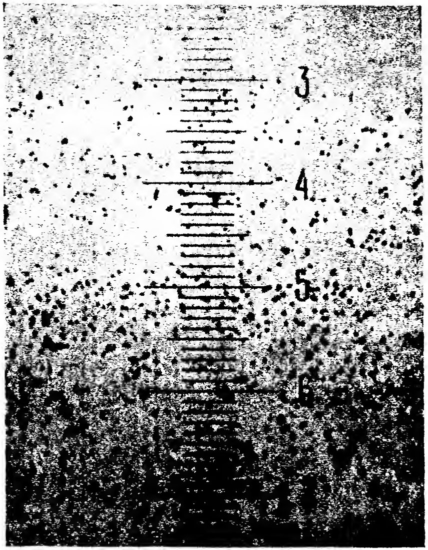


FIG. 15. Preparation of "elementary bodies" ("Paschen bodies") of vaccinia stained by Paschen's method, × 1187

(From *John Brown Buist*, by kind permission of the *Edinburgh Medical Journal*, N.S. (IVth), Vol. XLIV, page 72, 1937)

FIG. 16. Film preparation of staphylococcus and B. coli stained by Paschen's method, 1189

(From *John Brown Buist*, by kind permission of the *Edinburgh Medical Journal*, N.S. (IVth), Vol. XLIV page 72, 1937)

FIGS. 15 and 16. COMPARATIVE SIZE OF BACILLUS, COCCUS, AND "ELEMENTARY BODIES"

(By courtesy of publishers and Professors T. J. Mackie and C. E. Van Rooyen)

to see the form and shape of the smallest viruses like those of Foot and Mouth disease, and poliomyelitis $\frac{8}{1,000,000}$ of a millimetre. The life of viruses can also be gauged by ultra-filtration through collodion membranes of a known porosity, or by ultra-centrifugation in a specially rapid machine. By these methods particles as small as $\frac{1}{10,000,000}$ of a millimetre can be measured.

Through the kindness of Dr W. J. Elford, the following scale from the National Institute of Medical Research will give some idea of the relative sizes of viruses which are associated with certain diseases.

Sizes of Viruses in Relation to Bacteria and Proteins

Size in $\frac{1}{1.000,000}$ of a millimetre or $\frac{1}{25,000,000}$ of an inch

	as measured by microscope:
Bacillus prodigiosus (an average size microbe)	500–1,000
	measured by ultra-filtration:
Psittacosis Virus (Parrot disease)	200–300
Vaccinia (Cowpox) Virus	125–175
Hydrophobia Virus	100–150
Herpes Virus	100–150
Influenza Virus	80–100
Rous-Sarcoma Virus	75–100
Yellow Fever Virus	18– 27
Poliomyelitis Virus	8– 12
Foot and Mouth Disease Virus	8– 12
	measured by ultra-centrifugation:
Serum albumin (protein substances)	5
Oxyhæmoglobin (protein substances)	5
Egg albumin (protein substances)	4

It is as difficult to form a conception of the smallness of viruses, as it is to imagine the magnitude and distance of the stars, and one is lost in wonderment at the capability of science to measure with exactitude extremes such as these that elude our grasp when we think of them.

How can viruses be isolated and obtained pure? This is effected by chemical methods. Extracts are made from diseased material—like blood or sap—by successive concentrations and filtrations until a highly charged fluid is obtained which can be used for experimental purposes, and with some viruses in crystalline form.

Moreover, in proof that the purified product is the specific cause of a particular disease under investigation it can be shown to give " positive " reactions (agglutination or precipitation) when tested with the blood serum of animals suffering or recovering from the disease in question.

Viruses in chemical constitution belong to the " proteins " and as will be seen by reference to the Table of Sizes, the smallest are hardly larger than the molecules (the smallest unit of a chemical compound) of the protein albumins. Thus as regards *size* the smallest known particles which can be said to be endowed with life are not far removed from their neighbours, the molecules of inanimate matter. Here we seem to be on the very borderland of life, and it is difficult to restrain the conception that the boundary line in the future may be crossed by the biologist or chemist, and the old dictum " Omne vivum ex ovo " proved to be as fallacious as Dalton's Atomic Theory.

Another feature which certain viruses, and purely chemical substances have in common is that of crystallization, and chemical crystals in their formation and powers of assimilation and growth exhibit many of the characteristics of life itself.

One of the greatest difficulties in the study of viruses is the impossibility of growing them like bacteria on artificial nutrient media. They require for their existence to be cultivated inside a *living* cell. This difficulty has been overcome by the delicate method of living tissue culture. Animal tissues can be kept alive, and will even grow, if they are kept warm and nourished in appropriate fluids : and in these living tissues viruses can be grown, their virulence increased or modified, and their effects studied by inoculating animals or plants.

Another elaborate method has lately been employed, in spite of the difficulties of technique ; the embryo of the living chick is inoculated inside the shell, and the incubation carried on for longer or shorter periods without apparent harm to life or development if the chick is not susceptible to the virus under investigation. The chick harbours the virus which itself increases in quantity and strength *pari passu.*

In this way a quantity of viruses from various diseases can be obtained, and in some instances it has been possible to prepare a vaccine, e.g. yellow fever, which is being employed as a precaution or in treatment.

How is virus infection spread from animal to animal, or plant to plant ? Each virus requires its special method, and there are two main agencies : (1) Direct aerial, or contact infection. (2) Conveyance by living creatures, chiefly insects.

(1) *Direct Infection.* This is the probable source as regards influenza, measles, chicken-pox, mumps, poliomyelitis, and many other human infections ; the virus is conveyed in the breath, or droplets, or by contact with contaminated material.

(2) *Conveyance by living creatures*—chiefly insects.

The two best examples are Yellow Fever conveyed by a mosquito ; and Typhus Fever by the body louse.

In Yellow Fever the virus apparently requires a period of incubation of several days in the mosquito before it becomes infective to man, nor does it appear to be harmful to the insect which may harbour it for life. The infection is conveyed by the salivary glands during the bite.

In Typhus Fever, the virus (Rickettsia) lives in the stomach of the louse and is conveyed to the skin of man in its excrement. Scratching causes inoculation, and the blood becomes infected. Unlike the mosquito the louse itself is susceptible to typhus virus and dies in about twelve days.

A great deal of our knowledge of viruses has been gained in late years by researches on the diseases they cause in plants, their mode of conveyance and the means by which they can be controlled.

Here again infection through insects, or the smaller creatures of the animal world, is of frequent occurrence. Chief among the culprits are the species of aphis, green and black fly, and leaf hoppers. Potato degeneration, and leaf roll, mosaic disease, curly top of sugar beet, are conveyed in this manner—but cabbages, tomatoes, wallflowers, and many other plants and vegetables are subject to virus diseases and their intensive study at centres like the "Plant Virus Research Station" at Cambridge University is throwing light on this important subject which is of so great an economic consequence.

The study of Immunity, of Vaccines and Antitoxins, of Microbes and their poisons, is still in its infancy and the results already obtained by the imitation of Nature's methods hold out hopeful prospects for the future. In dealing with such minute and elusive material on the borderlands of life the difficulties are enormous, but already both Bacteriology and Biochemistry have placed in the hand of Medicine methods of rational treatment

far more valuable than anything hitherto known, which are taking the place of the old-fashioned bottles of medicine and other remedies on which so much faith and reliance were formerly placed.[1]

[1] I am indebted for much information on viruses to an admirable little publication *Beyond the Microscope* (Pelican Books), by Kenneth M. Smith, Esq., F.R.S., Director of the Plant Virus Research Station at Cambridge University.

Chapter XI

TROPICAL DISEASES

The discoveries of the real causes of many tropical diseases, which have been made during the last sixty years, and which have so entirely altered the conditions of life for both natives and white men, will always be associated with the name of Sir Patrick Manson, the Father of Tropical Medicine.

Sir Patrick Manson

He was born in 1844 at Old Meldrum in Aberdeenshire, and in 1866, shortly after his student days, went out to the Far East, first to Formosa, and then to Amoy in China, as Medical Officer to the English Settlements. He immediately became interested in the new and strange diseases with which he was brought into contact, and on which Medicine hitherto had shed no light. The average doctor occupying such a post concerned himself very little with scientific research, and was content if he performed his routine duties satisfactorily. Manson with no experience in laboratory work and very little medical literature at hand, had to train himself with makeshift instruments and an inferior microscope; and in a sub-tropical climate use up his leisure time for any research outside his official work or private practice.

The Chinese, who were his chief patients, were suspicious of foreign methods, and their ideas about disease and medicine were wrapped in superstition and traditional beliefs. On one occasion, when he was investigating a parasite which infests birds, he was prohibited from shooting a magpie, because the spirit of a former

Emperor had taken up its abode in this species, and it might be in the one he brought down. On another occasion he had to fly for his life from an infuriated mob, who broke in on him while making a post-mortem examination on an important case, and for which special leave had been given by the relatives.[1]

It was at Amoy between 1876 and 1883 that Manson made the great discovery that threw a fresh light on the origin of tropical diseases. Like Pasteur and Lister, he found a new field of research which in the hands of many subsequent workers has proved fruitful in solving the problems, and dissipating the erroneous beliefs of centuries.

First Discovery of Cause of Elephantiasis

The discovery was made in connection with a disease, which is limited to certain parts of the tropics, and is slow in its course. Huge enlargements of the limbs and other parts of the body occur, causing unsightly deformity; hence its name Elephantiasis. It was rightly supposed that these swellings were caused by some block in the channels which drain off the waste fluids of the tissues, and a very curious kind of worm some 3 inches long and as thin as a horsehair had been found in the swellings by a Dr Bancroft. It was also known that in the blood of these sufferers, and in many natives in apparent health, microscopic little creatures like bits of thread (*filaria*) encased in a delicate membrane could sometimes be found. But not always, for Manson working day and night, made the remarkable discovery that in a patient who harboured these creatures the parasites could be found in a drop of the blood only if it were

[1] For many facts on this and the pages immediately following I am indebted to the *Life of Sir Patrick Manson* (Manson Bahr).

taken at night time: in the daytime the blood was quite free from them. They must, therefore, have secreted themselves deeper in the body. He came to the conclusion that these little parasites were the embryos of the parent worm found in the swellings, but they did not appear to develop into mature worms in the same patient, and he thought they might need a change of host [1] before they could do so. If so, how did they get out of the blood? Where did they develop outside the body? In what way did they then find an entry into man again before they could grow into the obnoxious adult which caused the disease? All channels of exit from the body were examined with no results, and Manson then became convinced that the embryos must make their escape by means of some creature which fed on the blood of infected patients. Bugs, fleas, lice were thought of; but the disease was confined to the tropics and the most likely carriers would be mosquitoes. His joy may be imagined when after squashing a recently well-fed specimen on a microscope slide he found the blood in its stomach full of the parasites. This, however, was only the beginning of a long and patient investigation. For months he dissected and examined thousands of mosquitoes at different stages after they had bitten an infected patient. He traced the further developments inside the mosquito, finding that the embryos penetrate its stomach, change their form in its muscles, and eventually reach its saliva glands and stabbing proboscis in the shape of microscopic worms. When the mosquito bites a fresh subject the worms get on the skin, bore their way into a channel and there develop again into mature creatures three inches long. The marvel in this strange

[1] The "Host" of a parasite is the creature in or on which it lives. Not infrequently a parasite requires, during the stages of its development, one or more intermediate hosts of another species.

story is of course the manner in which the embryos have adapted their appearance in the blood to the same hours at night during which mosquitoes feed. How long did it take the parasites to find out that it was useless to put in an appearance at other times? And where in the body do they resort during the day?

In addition to revealing the part that may be played by insects, as disease carriers, Manson made many other discoveries relating to obscure complaints caused by parasitic forms of life in the Far East, and initiated the technique for future research. Later on in the 'nineties he left China and came to London, where he was instrumental in founding the London School of Tropical Medicine in connection with the Seaman's Hospital at Greenwich. In view of our numerous tropical possessions the Government recognized the immense importance of his work for the future well-being of the Empire, and by grants and other support encouraged this new branch of Medical Science. Manson came to be looked upon as a kind of referee to whom research workers in all parts of the world might apply for advice, and since he was a great teacher with the gift of inspiring enthusiasm, he was soon despatching numerous students overseas to carry on the fight against every kind of tropical disease. The successes which have already attended these efforts, and the means by which they have been achieved, form a real romance in Medicine, and the literature which describes them, with its account of complications and false scents, the final disclosure of the right clue and the triumph of the investigator, is as absorbing as a detective story.

As examples out of many which could be chosen, space will allow only a brief outline of those that may be called "The Big Three"—Malaria, Plague, and Yellow Fever.

Malaria

Malaria is not strictly a purely tropical disease, but has receded gradually from temperate climates with the advance of civilization, and the cultivation of soil which was formerly marsh or forest. Even now it is widely spread over all tropical and sub-tropical countries, and occurs in more temperate zones, as for example those round the shores of the Mediterranean. It has made vast districts uninhabitable and at the present time is still probably responsible for more deaths and illness than any other single disease. The prevailing theory as to its cause, as explained in Part I, gave rise to its name.

Laveran Discovers the Parasite

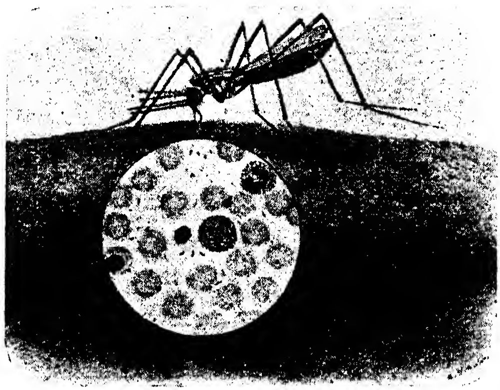
In 1878–80 a French doctor, Laveran, had noticed under the microscope little rounded bodies with particles of pigment in them, in some of the red blood cells of patients suffering from malaria. He suggested they were parasites and had something to do with the disease, but his observations were not confirmed or were discredited. Later on, however, these appearances in the blood were noticed by other investigators and a parasitic theory of the disease was revived as a definite possibility.

Although Manson was living in London about this time and had few opportunities for research on Malaria, he not only held that the disease had a parasitic origin, but, influenced by his previous discovery in Elephantiasis, published in 1894 a suggestion that a mosquito might be the conveyor.

Sir Ronald Ross Detects the Mosquito Carrier

Shortly afterwards, Dr Ronald Ross, of the Indian Medical Service, who was home on leave, came to consult

Manson about some research on which he was engaged, and was persuaded by him to undertake the task of searching for the parasite in different species of mosquito. The task was undertaken, and the account of the work it entailed is one of the finest records of human capability and persistence under every imaginable difficulty. Working eight hours a day for two years, in addition to routine



Diagram

FIG. 17. MOSQUITO SUCKING INFECTED BLOOD FROM A BLOOD VESSEL—OR CONVERSELY DISCHARGING PARASITES FROM ITS SALIVARY GLANDS

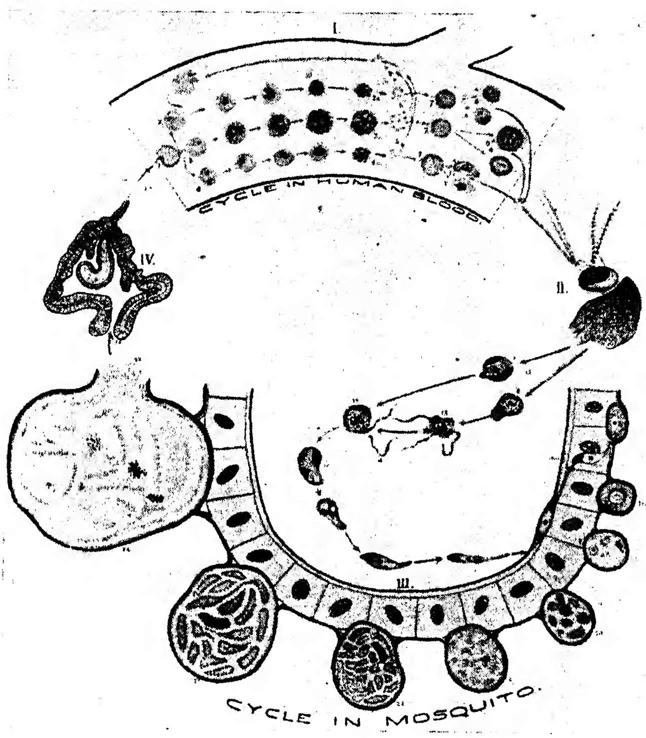
(By courtesy of K.E.F.)

duties, in a hot climate, Ross collected and kept different varieties of mosquito, dissected thousands, and examined under the microscope all parts of their bodies. His sight became affected, and his microscope rusty from sweat, and his search seemed futile; nothing in the body cells of the mosquito could be found which bore any resemblance to the supposed parasites in human malarial blood. And then one day, in 1897, he found the required evidence in the lining cells of the stomach of a certain

mosquito (a female Anopheles). This was only the first step. Stage by stage the life history of the parasite was unravelled. This in itself reveals a series of highly complicated transformations which it undergoes in passing through the body of the insect, until it is injected, during a bite, into the blood of a human being, where again another series of transformations takes place until the cycle is completed by its transference again to another mosquito's stomach.

It was shown in these researches that there are both male and female forms of these minute one-celled organisms, and that they multiply by sexual reproduction. Their union and the formation of thousands of embryos in the body of the female parasite, take place in the mosquito ; the embryos are " born " and, after development, find their way into the salivary glands of the insect and from there are discharged into the human blood during a bite. In the human body the embryos attach themselves to the red blood cells, and develop into different shapes—spheres, or crescents—some of which are male, others female ; others retain their filament form and multiply by simple division. They destroy enormous numbers of the blood cells, and their periodical reproduction is associated with corresponding attacks of fever in the patient. There are several kinds of malaria, malignant or benign, due to different varieties of parasite, but the commonest carrier is the female Anopheles mosquito. Male mosquitoes apparently are not bloodsuckers, but the females require blood to aid the process of reproduction.

All this intricate research on creatures which have to be magnified at least a thousand times before they can be seen was not carried out by Ross alone : he indeed worked out the complete cycle of the transformations in birds, which are subject to malaria, and an Italian



Diagram

FIG. 18. CYCLE OF MALARIA PARASITE IN MAN AND MOSQUITO

I. Blood vessel with corpuscles infected by malaria parasites in various stages of development

II. Mosquito (female) sucking blood and parasites

III. The parasites undergo complicated changes in the stomach of the mosquito: they then penetrate its wall—and further development occur in the cysts outside the stomach

IV. Finally, the embryos reach the salivary glands of the mosquito, and are ready to re-enter human blood

(From the Wellcome Museum of Medical Science)

(Grassi) confirmed a similar cycle in human subjects in 1898. Ross finally was able to infect 23 out of 28 healthy birds with malaria by allowing them to be bitten by mosquitoes which he had infected.

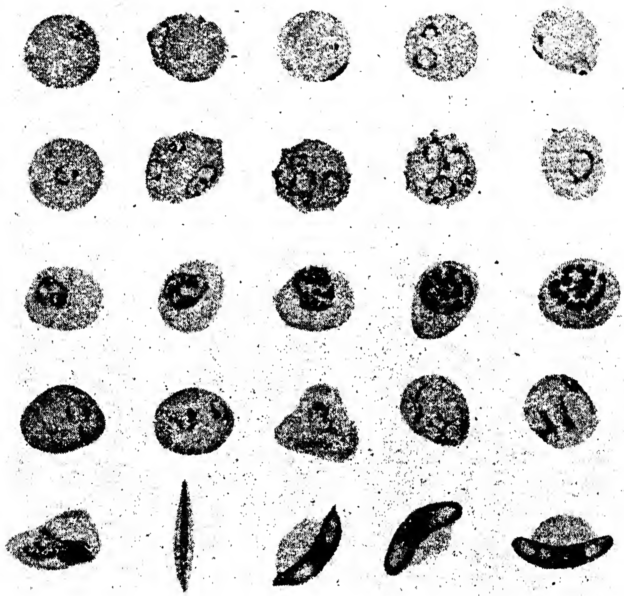


FIG. 19. VARIOUS STAGES IN THE DEVELOPMENT OF A MALARIAL PARASITE AS SEEN IN HUMAN BLOOD

(From Wenyon's *Protozoology*, Plate XIII. Baillière, Tindall & Cox)

Thus the scientific proof that malaria was carried by mosquitoes and not, as was formerly thought, by air or by contagion, was now demonstrated. Nevertheless, Manson thought that an even more convincing and dramatic form of evidence from human subjects would serve a good purpose, and he obtained a grant from

Mr Joseph Chamberlain to carry out the following experiment.

A mosquito-proof hut was constructed near Rome on the Campagna, one of the most malarious districts in the world, and almost deserted in the summer. In this hut two doctors (Sambon and Low) lived for four months in the height of the malarial season—they came out in the daytime, but retired inside before the onslaught of mosquitoes towards evening. They remained entirely free from any attack of malaria. Further proof that mosquitoes were the prime agents in conveying the disease was obtained by allowing a batch of them to feed on a patient in Rome suffering from malaria. With every precaution for their comfort and safety in travelling they were immediately despatched to England, and, hungry after the journey, they were allowed to bite Manson's son, and a laboratory assistant (Warren), neither of whom had suffered from malaria. Both these men developed an acute attack of the complaint, and parasites were found in their blood.

In both of the diseases just described, elephantiasis and malaria, the infection is conveyed by mosquitoes, but the parasite itself does not belong to the *bacterial* class of organisms. In the former it belongs to the Worm order, in the latter to the order of Protozoa, single-celled creatures of which the *amœba* is a type. Under the general term "disease" therefore must be included infections caused by parasites belonging to many of the different lower classes and orders of the animal kingdom, and it is especially in the tropics that such diseases, not strictly bacterial in origin, are found.

Sleeping sickness, and a form of dysentery, are other examples of disease caused by amœbic organisms; the parasite of the former being conveyed by the tsetse fly of Central Africa.

Prevention of Malaria

The tracking of the cause of malaria to its source by Manson, Ross, and others, necessarily led to the question of its prevention, the only solution being the apparently impossible task of exterminating the myriads of mosquitoes in large tracts of country. Yet this almost incredible work has already been undertaken and has largely freed many districts from the scourge of centuries. Sierra Leone in Africa, Panama in Central America, Ismailia in Egypt, and extensive parts of Greece, Italy, Ceylon, India, and the Malay States are notable examples. Success is limited only by the vastness of the areas, and the expense and labour involved, but we have at least gained the knowledge of how to attain it.

The annual world mortality from malaria must be enormous. In India alone it is estimated at 1,000,000 natives. In addition to the death-rate, countless numbers must be reckoned who are incapacitated, and suffer from chronic ill-health.[1]

The chief measures adopted for exterminating mosquitoes and preventing malaria, are :

1. General sanitation, including the draining of land, destruction of refuse, and clearing of tropical undergrowth near towns and villages.
2. Supervision of all known breeding places of mosquitoes, and, where draining is impossible, spraying with paraffin or other chemicals to kill the larvæ.
3. Protection of dwelling rooms by mosquito netting, and especially wherever malaria infected patients are being treated.

The administration of quinine prepared from cinchona

[1] Masters, op. cit., p. 149.

bark is still the favourite form of *treatment* for this disease, and it can now be regulated by noting the presence or absence of the parasites in the blood. Unfortunately the

FIG. 20. SPRAYING WITH PARAFFIN IN PANAMA

The larvæ of Mosquitoes live in water or marshy soil. They come to the surface to breathe, and are killed by coating the surface with a film of paraffin

(By courtesy of the Wellcome Museum of Medical Research. Dr S. H. Daukes, O.B.E.)

drug is expensive, and the demand far exceeds the average annual supply of about 600 tons. Of late years newer drugs have been introduced (atebrin and others), which

are on trial and appear to be even more effective than quinine, though these are also expensive.

Yellow Fever

Reference has been made in Chapter II, p. 19, to the ravages of Yellow Fever, especially in tropical America, the West Indies, and the west coast of Africa, and to the once prevalent idea that it was highly contagious, and originated from some poisonous miasm in the air. The tale of how its real nature and mode of conveyance were discovered is inseparably connected with the American occupation of Cuba, and its Capital, Havana, after the Spanish war in 1900, and with the cutting of the Panama Canal in 1904–8. The conquest of this disease by American doctors is a veritable romance of heroism and high endeavour.

Havana and Panama Canal

While the Americans were in possession of Havana, a terrible epidemic of Yellow Fever was raging, the hospitals were crowded with cases, and the mortality was exceedingly high in their army. No measures, including isolation and disinfection, appeared to stop the infection; and as there were so many theories of its origin a Medical Commission of four doctors—Carroll, Lazear, Reed, and Agramonte—was appointed to find out if possible the real cause.

The American Commission

They set to work. One great difficulty, however, met them at once: it had not been found possible to transmit the infection to animals, so that any experiments had

to be made on human beings. Years before, an old doctor in Havana had suggested that mosquitoes might be concerned with its conveyance, but he was considered a crank, and his theory had not been followed up. Nevertheless the Commission decided to investigate it and volunteers were called for. Mosquitoes of different kinds were collected after they had bitten yellow fever patients, and then, after varying intervals, were allowed to bite the volunteers. Carroll and Lazear led the way. In a few days both of them developed the disease in a virulent form, which proved fatal to Lazear, and brought Carroll to the point of death. In spite of this highly significant but disastrous beginning the experiments continued. It was found possible to convey the infection by injecting a volunteer with the blood of a yellow fever patient during an attack, even if the fluid part, or "serum", was highly filtered. This showed that the poison was a "filter passer".

Mosquito bites were very uncertain in inducing the disease; some volunteers caught it, some did not, but after endless research the reason for this was found out. It was discovered that only *one* variety of mosquito, out of many, could convey the infection, and even then it was only the female which was responsible This criminal creature has a long scientific name, *Stegomyia fasciata*. Then another remarkable discovery was made which proved that there was still another reason why so many failures in inducing infection by the bite method had failed. The *Stegomyia* cannot convey the poison after biting a yellow fever patient *until about twelve days have elapsed*. It is necessary that the filter-passing virus should undergo some transformation, or pass a phase of its existence, in the body of the insect during this incubation period of twelve days before it becomes virulent for human beings. If at this period or subsequently the

mosquito bites someone who has not previously had the disease (for an attack confers a lasting immunity), it conveys the infection into the blood, and after another incubation period of three to five days, the victim develops yellow fever. The " germ " or virus, therefore, has two phases of existence—one in the insect—the other in man, in this respect resembling its host the mosquito, which passes part of its life as a larva swimming about in water, and part as a winged insect buzzing about in the air searching for prey, and laying eggs in water.

All these exact and dangerous researches were carried out on volunteers from among soldiers and others who risked death from a dreadful disease. A reward of £40 was offered. The first two, Kissinger and Moran, replied, " We do not offer ourselves for the sake of money, and will only consent provided we are not paid for it."[1] Both were bitten by infected mosquitoes, suffered an attack, but recovered.

A party of three men underwent another and even more trying ordeal. It was important to find out if the current belief that yellow fever was contagious from man to man in the *absence* of mosquitoes, was correct. For this purpose a hut freed from mosquitoes and guarded carefully by mosquito netting was erected. In this hut for three weeks the volunteers slept wrapped in the soiled bedclothes of patients dead from the fever. None of them contracted the infection, though living in hourly expectation of its advent. Thus it was proved by these heroic doctors and volunteers that the *Stegomyia* mosquito was the culprit which harbours and conveys the infection; and that *preventive* measures must be chiefly directed towards its destruction.

[1] Masters, op. cit., p. 135.

The Work of Gorgas

The freeing of Havana from yellow fever is one of the marvels of Medical science. It was taken in hand by W. G. Gorgas, the American Sanitary Officer, and a regular campaign against mosquitoes—including the malaria carriers—was instituted. Since the Yellow Fever insect is domestic in its habits, living and breeding in and around dwelling-houses, and its larvæ are found in pools, cisterns, and neglected water in household vessels, it is far more easily destroyed than the malaria insect, which lives farther afield in gardens and the jungle, and flies in the evening to houses and huts to get its meals. Gorgas's measures included: (1) a vigorous supervision of all water supplies in houses; (2) the draining of any collection of water in ruts, pools, etc., round about houses; (3) spraying likely breeding places with paraffin to kill the larvæ; (4) the isolation of all yellow fever patients in mosquito proof huts.

Havana in 1901 was swept and cleaned, if not garnished, and the table below shows the immediate results obtained.

Deaths in Havana from Yellow Fever [1]

Year.	Deaths.	Year.	Deaths.	
1896	1,282	1901	18	Gorgas begins work
1897	858	1902	0	
1898	136	1903	0	
1899	103	1904	0	
1900	310			

In 1904 the United States renewed the attempt to construct the Panama Canal which had been abandoned by the French in 1888, owing in large measure to the

[1] Singer, op. cit., p. 279.

loss of life from malaria and yellow fever; their defeat had in fact been caused by an unsuspected enemy—a small insect.

Building of the Panama Canal

Gorgas adopted the same methods which had been so successful at Havana; but the Canal zone, amidst swamps and jungle, was a much more difficult problem, and the tracking and killing of the mosquitoes a seemingly impossible task. The story is too long to be told here, and must be read in detail to be appreciated. The attempt was successful: the death-rate in five years was reduced to one-seventh of that which formerly existed, and the Canal was completed in 1915–16. £4,000,000 alone were spent in fighting the mosquito.[1]

Use of Fish in Prevention

A very ingenious method of getting rid of mosquitoes both for malaria and yellow fever is the employment of fish. Barbados is the only one of the West Indian islands comparatively free from malaria, and its waters swarm with tiny fish called "millions". It was suggested that the freedom from malaria might be due to the fish eating up the larvæ of the mosquitoes. In 1920 an epidemic of yellow fever broke out in Peru. Immense numbers of small fish were caught and distributed in all the ponds, waste waters, and tanks near dwellings in the infected areas. Within six months the epidemic was stamped out, or it might be said eaten out, and this was accredited to the minnows and their kind.

By means of later research into the nature of yellow fever, in which two more doctors—Noguchi and Adrian

[1] Masters, op. cit., p. 144.

Stokes—lost their lives, it has been found that the disease can be conveyed to certain species of monkeys (Rhœsus) and that an antitoxin can be prepared to counteract it. It may, therefore, be hoped that further sacrifice of human life will be unnecessary.

The organism or virus which lives this dual life in man and mosquito still remains undiscovered,[1] in spite of the fact that so much is known of its life history and its effects, and how it is now possible to defeat them. Of all the fierce animals which inhabit the jungles, and swamps of tropical countries the mosquito with its slender figure and lace-like wings is by far the most to be dreaded ; and the little prick of its stabber which hardly wakes us from sleep may be more deadly than the horn of a charging buffalo, or the claw of the tiger.

Plague

Reference has been made in Part I to the devastating epidemics in former times of Plague, or the Black Death, and to the fact that it still occurs locally in the Far East. The last great epidemic, affecting China, India and other Eastern countries, occurred in 1894, and its scientific investigation began at Hong Kong, during the epidemic, with the discovery by Yersin, a pupil of Pasteur, and Kitasato, a Japanese bacteriologist, of the bacillus which causes the disease.

Discovery of Bacillus

There are two varieties of Plague : (1) the bubonic, in which swellings or " buboes " appear in different parts of the body, and (2) the pneumonic, which attacks the lungs. The former, in which the mortality is about 60 per cent., is not air borne : in the latter, which is

[1] See page 115.

almost invariably fatal, the infection may be conveyed through the breath or immediate surroundings. The bacilli found in both forms appear to be identical, but the exact relationship between the two has not yet been found out.

The bacillus is a spindle-shaped organism with a dark spot at each end and it was found both in rats and human beings suffering from plague. In either instance the discoverers were able to make pure cultures and from them reproduce the infection in healthy animals and again recover the same microbe from their bodies.

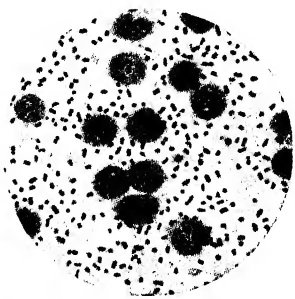


FIG. 21. PLAGUE BACILLUS IN BLOOD, × 1000

(By courtesy of Prof. Mervyn Gordon, F.R.S.)

That an increased mortality in the rat population always coincided with a human epidemic of plague had for ages been a common belief,[1] and that this was due to the same cause was now established. But it was inconceivable that rats themselves by bite or contact could be responsible for such widespread dissemination and incidence among all classes of human beings.

[1] A remarkable instance of an epidemic which was probably plague and its connection with mice—or possibly rats—is mentioned in the Bible (1 Samuel v. vi). The Philistines had captured the Ark of the Lord from the Israelites and placed it in the temple of their god, Dagon, whose image the next morning was found broken on the ground. At the same time the inhabitants of the city, Ashdod, were smitten with " emerods " (buboes) and the same fate befell the citizens of four other cities to which the ark was promptly transferred. " The Lord smote the men of the city both small and great and they had emerods in their secret parts," " and there was a deadly destruction throughout all the city and the cry of the city went up to heaven." The priests ordained that the ark should be returned to Israel with a trespass-offering in the shape of images of " Five golden emerods and five golden *mice* that mar the land " ; so that the plague might be stayed.

With Manson's discoveries in mind, it was considered that there must be some intermediate agent which conveyed the complaint from rat to man or vice-versa, and it was not unlikely that the flea, which is a common and unwelcome visitor to both parties, might be the culprit.

The Rat Flea

Now it is said that there are at least a hundred different varieties of fleas and they all have their particular tastes ; dog fleas, poultry fleas, hedgehog fleas, and so on, including the human flea (*pulex irritans*). Some of them keep to the particular species of animal they infest, but others like to vary their diet, and among these is numbered the rat flea, which will jump long distances to reach a human being and obtain a change of scene and food.

In the blood found in the stomach of fleas which have fed on infected rats the bacilli of plague may be found in countless numbers ; they appear to undergo no transformation in the stomach, but when the flea visits another animal the germs are injected during the bite, or, as often happens, the overful creature vomits up the surplus of old blood, on the clothes or skin of the victim. Thus it is easy to see that, by scratching, men or animals may infect themselves.

A number of ingenious experiments were needed before the discovery of the parts played by the rat and the flea in the spread of plague was made. The first question to be answered was whether a diseased rat could infect a healthy rat if both of them had been previously freed from fleas.

To free a rat from fleas is rather a troublesome task, and with plague about a very dangerous one. The operator has to be encased in a flea proof covering. The

rats were lightly sprinkled with chloroform to stupefy the fleas, and the fur combed out thoroughly with the greatest care. Then three or four plague infected rats freed from fleas were placed in a cage with three or four healthy rats also freed from fleas, and they were all well fed to prevent any chance of fighting. In due course all the infected rats died, and all the healthy rats remained *free* from the disease, and this proved that in the absence of fleas the bubonic form of disease is not *contagious.*

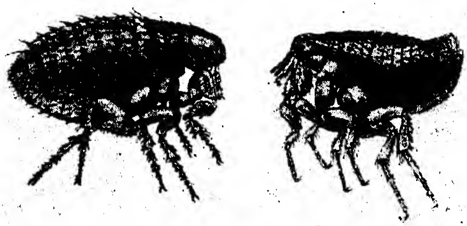


FIG. 22
1. Female Rat Flea. 2. Male
(By courtesy of K.E.F.)

The next step was designed to find out if infected rats *with* fleas on them could convey the disease to healthy rats through *the air alone.* It was necessary to place the cages as near together as possible but beyond the jumping distance of the fleas. This again was not easy; in fact, athletic trials were held to find out a possible Olympic champion among the fleas, and a flea jump record, and this having been found (unfortunately the number of inches is not recorded) the cages were hung in the air in varying positions, but always separated by a distance just exceeding the longest jump! Very soon all the diseased rats died, but the nearby cage of healthy rats remained

free of disease. This proved that the bubonic form of the disease was not conveyed through the air. The final experiment proved that the flea was the carrier.

A rat dying from plague and infested with fleas, was placed in a double cage, in the other compartment of which were healthy rats freed from fleas. In due course the infected rat died, and, as is always the case, the fleas deserted the body, and crossed the bars to the healthy rats, all of whom afterwards caught and died of the disease.

There are other rodent animals besides the rat which are infested with fleas that convey plague. The marmot, an animal like a large guinea pig, an inhabitant of the cold mountains in Manchuria, north of China, and the ground squirrel of California are both subject to infection, and, in China trappers travelling south to sell the skins, bring the infection with them. With a flea infested population it is easy to see how quickly an epidemic may spread, and be conveyed by rats on ships to foreign countries.

Prevention of Plague

To get rid of fleas altogether would, of course, be the best proceeding for both man and rat, but how often we have reluctantly to own defeat by only one flea ! and what can be done to destroy them in their thousands ?

Short of this ideal the chief measures to prevent the spread of plague would appear to be the destruction of rats, the isolation of plague patients, and strict examination and quarantine of all vessels coming from infected parts of the world. One of the chief difficulties is the low standard of life among native populations, and their dislike of any interference with their customs and mode of living. Fleas and rats are part and parcel of every household, and interfering Sanitary Officers, who preach strange

doctrines, and come to inspect and purify houses, are not welcome.

Several ingenious ways of getting natives to take an interest in the killing of rats have been invented. In Formosa a rat lottery takes place and for every dead rat a ticket is given; when about 100,000 tickets have been issued the winners receive handsome prizes.[1] In South

FIG. 23. A RAT CLIMBING A SHIP'S HAWSER
(By courtesy of K.E.F.)

Africa when an epidemic was threatening to invade a large native district, a resourceful missionary had a happy idea. He arranged that for a few weeks the small fees paid by the natives for attendance at the Missionary Schools should be settled by rat tails in place of coin! Every day the children brought their rat tails, which were solemnly burnt in a bonfire, and carried home instructions for the burning of the bodies left behind. A "Rat Tail Sunday" also

[1] Masters, op. cit., p. 163.

took place, with a sermon on Plague and rat destruction, and the sidesmen we suppose collected tails instead of coppers at the end of the service ! [1]

There are, of course, dozens of ways of killing rats or preventing their entrance to houses ; but they are the most cunning of all pests in evading traps, baits, or other contrivances, and so fertile in their multiplication that sooner or later they reappear.

On ships, where escape is impossible, they can be exterminated altogether by fumigation with poison gas, and this is by far the most effectual method. Afterwards the entry of fresh rats, except in bales of merchandise or in the loading of cargo, may in part be prevented by fixing special saucer-like guards on the hawsers which moor the ship, and along which the rats might run, or by illuminating the side of the vessel at night.

Haffkine's Vaccine for Plague

Before the discovery of the bacillus in 1894 no effectual treatment had been found for plague. In 1896, during the Indian epidemic, W. Haffkine, a pupil of Pasteur and a Russian by birth, but in the service of the British Government, introduced a vaccine which has proved of great value both as a protective, and in reducing the mortality of the infected. The test of this vaccine entailed a very courageous act on the part of its originator. The poison of the disease is contained in the bacilli themselves and not in the nutrient medium in which they grow, and the vaccine is made by killing the germs and preparing a solution of their dead bodies. It is possible to reckon the average numbers contained in a drop, or a cubic centimetre, but the effect of an injection, and its required strength had yet to be ascertained on a human being.

[1] Gollock, *Heroes of Health*, p. 91. (Longmans, 1930.)

Haffkine had the tests carried out on himself, knowing that they might be fatal. Fortunately the reckoning was not far out ; he suffered from a mild attack, and afterwards was able to regulate the strength of his vaccine and the number of injections required to act as a safeguard to the healthy, or as a remedy for those already stricken. Anti-plague precautions and the modern treatment by vaccines have, however, to contend with the prejudices of the natives in regard to general sanitation in health and their fatalism in the presence of disease, and in spite of all that is being done, 10,000,000 deaths from plague alone were recorded in India betweeen 1898 and 1918.[1]

Examples have now been given of four tropical diseases caused by different classes of microbes or parasites.

Disease.	*Cause.*	*Conveyor.*
Elephantiasis	Worm	Embryos by mosquito
Malaria	One-celled parasite	Embryos by mosquito
Yellow Fever	A filter passer virus	Mosquito
Plague	Bacillus	Rat flea

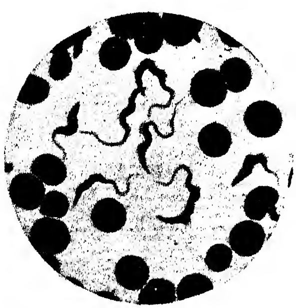


FIG. 24. SLEEPING SICKNESS Trypanosome in the blood, × 1000, conveyed by the tsetse fly

(Prepared by Prof. Mervyn Gordon, F.R.S.)

In addition to these there are many other diseases, the causes and conveyors of which have been identified during the last thirty or forty years, and the prevention and treatment of which has been placed on a scientific basis. Malta fever has been defeated by the discovery that it was the goat which was the host of the germ, and the Sleeping Sickness of Central Africa has been

[1] Topley and Wilson, op. cit., p. 1283.

tracked to the tsetse fly, and new methods have been evolved for its treatment.

Humanity owes an unpayable debt to those who are devoting, and have often given, their lives to researches, which are leading not only to an incalculable relief of suffering, but are shedding a fresh light on some of the great mysteries of Nature.

CHAPTER XII

BIOCHEMISTRY

Ductless Glands and Vitamins

IN dealing with modern methods of treating disease some account must be given of certain invaluable new resources afforded to Medicine by the discoveries made in Biochemistry since the end of the last century. The subject is far too technical and abstruse to be discussed in detail here, but a very brief outline of the main facts will be sufficient to indicate that along this line of research the most important future developments in Medicine may be anticipated. It is impossible to analyse the *living* cell of any organ by laboratory methods, because in so doing its essential characteristic, *life*, is destroyed. Apart from life, however, the chemical elements of which it is made can be ascertained, and if its function has been to form secretions, or products which serve a purpose in the bodily economy, it is possible, even if they cannot be analysed, weighed or measured, to collect and test them by their effects. Milk, for instance, a secretion of the mammary gland, can readily be analysed, while the "antibodies" found in the blood, which resist infections and confer immunity, can only be tested by their effects. The latter were discussed in Chapter IX, under Bacteriology, although, strictly speaking, they are in the domain of Biochemistry

From the practical point of view the most fruitful discoveries made by the Science of Biochemistry in the last forty years, and the new methods of treatment which they have led to, are concerned with the functions of certain

little *ductless glands* found in different parts of the body, the importance of which had been almost entirely overlooked.

The Ductless Glands

The ductless " glands " are very different in structure and function from the lymph glands which feel like peas or almonds under the skin, and are found in the neck, armpits, or groin, and sometimes get enlarged and painful or are the seat of abscesses. The lymph glands act as fortresses of defence, placed along the lymph channels which drain the tissues. They contain vast numbers of lymph cells, which filter off and destroy germs and poisons which would otherwise reach the circulation ; they act in a sense like a grease trap in a drain, or a purifying filter-bed in a waterwork.

Then, again, there are certain glands provided with ducts or outlets through which their secretions are poured to serve some useful purpose ; for example, the tears for our eyes ; the saliva ; the bile ; the pancreatic juice for digestion ; the kidney and sweat glands to get rid of excess of fluids and waste products. The functions of all these were for the most part well known.

But it was far otherwise with what are known as the " ductless glands ", many of which were looked upon as useless, or as relics of a far-off pre-human ancestry. Within the last forty years it has been found out that these little structures play a very important part in the bodily economy. They manufacture extracts, or secretions called *hormones* (from a Greek word meaning to excite, or stir up), which are carried away by the circulation to all the different organs and tissues of the body, and act as *regulators* of the amount of work and output to be performed by each in accordance with the immediately

required need. They can *stimulate* one organ to greater activity, or *depress* another to work more slowly, and to parts which require to act in harmony they are as it were *messengers* keeping each one informed of what the other is doing. In this way a proper balance is kept between all the activities of the body from the brain downwards to the internal organs, the muscles, bones, skin and hair. At no time is it more necessary that this balance should be kept than during the period of our growth and development; otherwise one structure might outstrip or lag behind another, or, failing a general stimulus, growth and development might be entirely arrested.

Fortunately for us, these little ductless glands do not often go wrong, but there are quite a number of diseases, as well as some disorders of our growth and general make-up, which depend on too much, or too little, or the absence of the substances which they supply. The causes of these disorders were among the outstanding puzzles of Medicine, until Biochemistry and Physiology quite recently offered a solution of the problem which, however, is still far from complete. A few examples will make this clearer.

The Thyroid Gland

The ductless gland about which our knowledge is most complete is called the "Thyroid". It lies on each side of the windpipe in the neck close to the "Adam's Apple", connected by a narrow bridge which crosses in front of the air passage. In some people it forms a quite distinct enlargement in the neck known as a goitre, and occasionally becomes as large as an orange or coconut. This condition is especially prevalent in the narrow valleys of certain mountainous and limestone districts in Switzerland and elsewhere, and has been attributed to an excess of lime in

the water, or to a deficiency in the supply of iodine which the body requires in small quantity. In these same districts many of the children suffer from arrested development; they are known as Cretins. They become dwarfs with unsightly heads, faces, limbs, and defective speech, and their minds remain childlike, or are idiotic from the beginning. In these children the thyroid glands are found absent or wasted. Another condition, which, though not common, is more general in distribution, is a disorder called myxœdema: it mostly affects women of middle or early old age, and as a consequence they become slow in mind and body, with coarse features, a dry skin, and loss of hair. Here again a deficiency or disappearance of the thyroid gland is found. On the other hand in some cases where an enlargement or goitre is present, with an excess of its secretion, a very different picture is presented. The extra stimulus causes an abnormal excitability both in body and mind; the heart beats more frequently, and the eyes become prominent and staring, as may occur in sudden frights or alarms. Now it is sometimes necessary on account of obstruction to breathing, or for other reasons, to remove goitres in the neck, and when this operation had been made safer by antiseptic surgery, it was undertaken more frequently. It was found, however, that if the gland was removed *completely*, although the *object* of the operation had been successful, a certain number of the cases afterwards developed the above-mentioned condition of myxœdema. Experiments were then made to find out what effect, if any, the removal of this little gland in the neck would have on quite young and growing animals. It was found, for example, that the growth of lambs was stopped, they became stunted and less playful, and never grew up into proper sheep. And so with other young animals. Even tadpoles have been used, and in spite of the difficulties with such small

creatures, when their thyroid glands are taken away they never grow up into frogs with legs, but keep their tails, and their tadpole habits. On the other hand, if tadpoles are fed with thyroid extract, they lose their tails and develop into frogs more quickly than their brothers and sisters who are not given this stimulant.[1]

Clearly, then, the thyroid gland possesses some product which performs a very important function, in its effect on growth and nutrition and mental development. Moreover it was not long before the striking discovery was made that this product could be extracted from the glands of sheep or calves, and if given to cretins would gradually bring about their proper mental and bodily development, or would restore to natural appearance and health the sufferers from myxœdema.

The effect of giving a tiny tablet of this extract, as a part of their food, to these sufferers, who would otherwise be condemned to a deformed and useless existence, is one of the marvels of Medicine. The extract supplies a deficiency which was ruining their lives, and does not even require to be injected into the blood, but can be taken by mouth, as its effect is not destroyed by digestion. It is necessary, however, to continue its use for the rest of life since it does not *restore* the function of the inefficient gland, but only acts as a substitute. It was a triumph of Biochemistry when the active principle of the Thyroid gland was isolated in 1914 as a definite compound—called Thyroxin—and a still greater triumph when in 1926 this compound was produced synthetically and found to possess, though to a lesser degree, the remedial powers of the natural secretion.

Moreover, the discovery of Thyroxin revealed the secret of the thyroid gland and how it works. This compound is rich in iodine, one of the essential requirements of the

[1] Masters, op. cit., p. 236.

body tissues, and the chief function of the gland is to keep it in store and issue it as required in the form of thyroxin or its derivatives. The thyroid itself is supplied by the iodine found in our food or drink. For many years past and before the reason of its utility was known, iodine was a favourite remedy for goitre, and in ancient days was given in the ash of *burnt sponge*, which like seaweed contains

FIG. 25. CRETINOUS INFANT BEFORE AND AFTER THYROID TREATMENT
(By the courtesy of the Clarendon Press, Oxford, from Singer's *A Short History of Medicine* from the Collection of the Royal College of Surgeons)

this element.[1] In Alpine districts iodine in some form is now regularly given to the schoolchildren, and with the knowledge we now possess, goitres and cretinism will become rare instead of being common disorders.

The picture of a Cretin will afford a better illustration of the wonders effected by this magical substance than many pages of description. As previously mentioned, trouble may be caused by an excess of thyroid secretion,

[1] Harrington, *British Medical Journal*, January 1936, p. 1269.

and in many cases relief can then be given by removal of the greater part of the gland, provided that sufficient is left to carry on its natural function.

The Adrenal Glands

Two ductless glands, the function of which were entirely unknown until the end of the nineteenth century, are known as the " Adrenals ". In shape like a little cocked hat, and about the size of an almond, they lie one on each side, tucked away at the top of the kidneys.

In 1855 a very able physician, Dr Addison, of Guy's Hospital, had noticed that a certain disease which now bears his name, and is characterized by extreme weakness, feeble heart action, and a curious bronze discoloration of the skin, was always associated with disease of these little glands. This observation suggested that they served some purpose ; but it was not till 1894 that the discovery was made that an extract made from the glands had a very definite effect when injected into a vein or the tissues of the body. This extract causes a contraction or tightening up of the arteries and small blood vessels, and consequently a rise in the blood pressure. The product of the gland was isolated in pure crystalline form in 1901 and is known as " Adrenalin ". It has become one of the most widely used and powerful remedies for hæmorrhage, shock, and heart failure, and there are now many cases on record when, by injection into the heart itself, during an operation, it has started again the beats which had stopped, and as it were by a miracle restored the dead to life.

It is a curious fact about these adrenal glands that the " cortex " or rind is different both in structure and function from the interior part. The former alone is connected with " Addison's disease ", while it is only the latter which yields the powerful extract used in Medicine.

Chemistry has recently gained yet another triumph with the laboratory *synthesis* of "adrenalin". The artificial product, however, though chemically identical, is not as potent as the natural, the dose of which is not more than a few drops of a solution of 1 part in 1,000 of water.

Unlike thyroid extract, adrenalin is destroyed in the stomach and can, therefore, only be used by direct injection into the tissues of the body.

The Pancreas and Insulin

The discovery in 1922 of a substance called "Insulin" is perhaps the greatest achievement of Biochemistry in recent years, since it has provided Medicine with an efficient remedy for Diabetes, a disease which hitherto had been regarded as hopeless.

It is difficult to resist the thought that the hiding-place of this precious substance in another large gland, which serves an entirely different purpose, must have been specially designed for its concealment and for preventing any intrusion on its privacy.

The large gland is the Pancreas or Sweetbread, provided with a well-marked duct through which flows into the intestine the pancreatic secretion, the most powerful of all the digestive juices. The performance alone of such an important function might well be considered a sufficient purpose for any single organ of the body; and the presence of a duct for its juices seemed to negative any idea that within this gland there existed another secretion which required no outlet, but was absorbed directly into the circulation. Nevertheless, this was the case. It was a well-known fact that disease or degeneration of the pancreas was often found in cases of Diabetes. Moreover, since the removal of the pancreas in animals had been

found to bring on diabetes, it was evident that this gland had some important connection with the disease.

The essential characteristic of this complaint is an excess of sugar in the blood, and its presence in the urine. In health the energy, heat, and nutrition of the body depend chiefly on the absorption and combustion of sugar by the different tissues. The assimilation of sugar is a very complicated affair, and its details are not yet fully known. It is necessary that a certain amount for the use of the tissues should always be available in the blood ; but this amount must be almost constant (from 0·08 to 0·12 per cent.), or vary within very narrow limits. During digestion much more starch (which is converted into sugar), or sugar itself, is absorbed than is required by the blood. The excess is stored up in the liver, as *glycogen* (a starch which is convertible into sugar) ; and in the intervals between digestion, a sufficient amount of this glycogen is converted into sugar and set free into the circulation, to keep the tissues supplied with their proper quota. In other words, there exists some regulating mechanism which issues *regular* rations of sugar out of a store *in a form* which can be assimilated by the tissues. The form is important, since the tissues can make no use of crude grape sugar (glucose) or cane sugar. The pattern of the atoms forming the molecules must perhaps be re-arranged, or the sugar requires something added to it ; or the tissues themselves require a stimulus before this essential constituent of food can serve its purpose.

In diabetes this regulating mechanism goes wrong or the necessary additional substance is wanting. Too much sugar is issued to the blood, and in a form which the tissues cannot use. In the midst of plenty they starve, and the whole body weakens and wastes and lacks energy ; the kidneys strive to get rid of the useless sugar, and thirst strives to supply the water they so constantly demand.

The condition was a sad one, and still sadder, because incurable, if life was prolonged over many years.

Now, since, as we have seen, there appeared to be some relation between disease of the pancreas and diabetes, extracts made from the gland were tried as a remedy, but were found to have no effect on the conversion of the sugar, or the course of the disease. There seemed to be no solution of the puzzle until the arrival on the scene of Dr Banting, a Canadian. The way in which he found one reads like a fairy story, or an exploit of one of the classical heroes such as Jason's quest for the Golden Fleece. For in Banting's search there was the magic essence, the islands where it might *perhaps* be found, the difficulties to be overcome in approaching them, and finally the conquest of the guardian dragon set to destroy the essence before it could be captured.

Among the ordinary cells of the pancreas are found here and there others of different structure grouped together like islands in an archipelago, and not provided with ducts for the outlet of any secretion. These groups of cells are called after their discoverer the "Islands of Langerhans"—a name which in itself suggests adventure, like "Lilliput" or "Laputa" in *Gulliver's Travels*. On account of their scattered disposition these pancreatic islands cannot be separated from the main body of the gland, and examined as separate units. Banting, however, conceived that they might in some way be concerned with the transformation or storage of the body sugar, and so with diabetes, and he set out to find a way in which their internal secretion (if any) could be obtained *apart* from the digestive juice of the surrounding gland. At the outset, an apparently insurmountable difficulty was encountered. The chemical ferments in the pancreatic *juice* remain active for some time after death, and immediately begin to digest or destroy the cells in which they have

been formed, as well as the isles of Langerhans, and any treasure they contain. The dragon was not done with when it was dead, and the still active juice might account for the inefficacy of extracts made from glands or sweetbreads even when they were obtained from freshly slaughtered animals.

The only possible way of obtaining any treasure hidden in the islands, or manufactured there, was to obtain it during life ; and at a time when there was no pancreatic juice in the body of the gland. How in the world could this be done ? Banting found a way.

It had previously been found that the secretion of pancreatic juice does not begin until a few hours after the birth of an animal. The stimulus of food in the stomach is required to start the mechanism which afterwards works automatically. The stomach lining, in fact, secretes a hormone or messenger (secretin) which keeps up communication with the pancreas to tell it that something is coming down, and to get busy.

Banting argued that if he could get hold of a pancreas before it had received its very first message, the extract of the whole gland, free from juice, might contain the *unimpaired* internal secretion of the isles of Langerhans (if by good luck these cells were already in action before or at birth). He obtained glands from calves *immediately* after birth, made his extracts, and injected them into animals suffering from diabetes artificially induced. The sugar with which their blood was loaded was almost immediately reduced, and this proved that the treasure islands of Langerhans yielded the magic essence which was necessary for the elaboration of sugar and its consumption by the tissues of the body.

Moreover, another way was found of obtaining the same result. If the main duct of a secreting gland is securely tied so that its secretion is stopped, the cells

which make it cease work, the manufactory shrinks and closes down and eventually disappears. A subsidiary undertaking, however, may be able to continue for a time, and this was found to be the case with the pancreas and its islands of Langerhans. If the main duct is tied the juice producing cells stop secreting, and eventually shrink up ; any juice left behind is absorbed, and when this has happened, an extract of what remains of the gland is found to be effective in its action on the sugar of diabetes. Only very small quantities of extract could be obtained by either of the above methods, but Biochemists have now discovered a way of extracting the pure product in crystalline form from the sweetbreads of recently killed animals. This is called " Insulin " (Latin—insula, an island), and its injection in standardized doses is largely used in cases of diabetes to regulate the amount of sugar in the blood and its combustion in the tissues. It does not *cure* diabetes, but supplies the lack of the natural secretion, and must be continued for life.

This remarkable achievement by Dr Banting was made when he was quite a young man, and not very long after he had taken his qualifying degree. When he was a medical student he gave up work to go to France and fight in the Great War. He was badly wounded, and invalided home, but after a time was able to resume his studies. He had to make his living, and after qualification started a practice, though his heart was in research work, and his mind obsessed with the idea of discovering the cause of diabetes, and succouring its victims. The obsession mastered his private interest ; he gave up his practice and returned to the University of Toronto. He impressed the Authorities with his earnestness and capability, and obtained a small grant to enable him to live while he conducted his proposed investigations. His plans were well laid, and his genius found ways of over-

coming all the difficulties of his venture, until success finally crowned his work.

There are all the elements of a romance in the story of this discovery, and it requires very little imagination to transform the details into the material which form the groundwork of the old classical myths, or mediæval tales and poems of adventure.

The Pituitary Gland

One of the most interesting of the ductless glands is the Pituitary (Latin—pituitra, phlegm).[1] It may almost be considered as the master of them all, for it takes some part in most of the functions of the others, by controlling or balancing their action, as well as performing services peculiar to itself. Moreover, it certainly has pride of place, for it is situated immediately under the brain in a little hollow shaped like a seat or saddle at the base of the skull, and known as the "Sella Turcica" (Latin, Turkish saddle), or Pituitary fossa (Latin, pit). It is about the size of a hazel nut and a short stalk connects it with the overlying brain. From this commanding position it provides secretions which are absorbed into the blood and carried to all parts of the body, controlling and co-ordinating the activities of the different organs and tissues, more especially during growth and development. There are two lobes or divisions of the gland, the front or "anterior", and the back or "posterior". In microscopic structure the "anterior" lobe of the gland differs from that of the "posterior", and their respective functions are also entirely different.

Anterior Pituitary. Much still remains to be ascertained

[1] The gland was formerly supposed to collect "humours or phlegm" from the brain by means of its stalk and discharge them through the skull into the gullet or nose.

of the part played by this portion of the gland in the bodily economy; but it is certain that it exerts an important influence during growth, especially on the bones and cartilages of the skeleton. If, for example, the anterior lobe fails to develop properly, or its function is impaired by disease, there is a lessening of its secretion. If this event happens *during infancy or childhood*, the bones and cartilages of the joints fail in their development or become deformed; the stature is dwarfed, and the limbs are short and clumsy. These deviations from the normal are often accompanied by a failure of development of the sex glands, which remain infantile. In other cases a child of eight or ten years may appear prematurely aged and resemble an old man or woman in appearance. An insufficient supply of secretion is also believed to account for the over fat unwieldy children one sometimes sees who, though big in size, are often weak in strength and general alertness and become sleepy and lazy (like the Fat Boy in Pickwick). A similar insufficiency may also account for excessive fatness in adults (e.g. the fat women of the Fair). It is probable, therefore, that the anterior pituitary secretion also controls the deposit of fat and regulates its consumption by the tissues.

On the other hand, what happens if for any reason, such as *overgrowth* of the gland, there is an *excess* of secretion of the anterior pituitary? If this occurs during development in *childhood*, the frame of the skeleton and the bones of the limbs grow too much and the child becomes a giant—tall indeed, but out of proportion in breadth and strength; and these so-called giants (also to be seen at "shows") are often weak and clumsy in movement.

Should over-secretion be *delayed* until maturity, its effect does not produce a giant, but an *irregular* over-growth of bone occurs, giving rise to curious deformities of the skull, face and limbs. The hands and feet become huge in size,

the jaws prominent, and the skull enlarged and bossy. Not infrequently an early symptom is a progressive need for larger hats, boots and gloves.

FIG. 26. GIANT AND NORMAL MAN
Age 35. Height 6 ft. 6 in. Weight 281 lb. Chest 50 in. Middle finger 4½ in. circumference. Hands and feet enormous

From *The Pituitary Body and its Disorders*, by H. Cushing. (Reproduced by the courtesy of Messrs J. B. Lippincott Co.)

Unfortunately, extracts made from anterior pituitary glands of animals have hitherto been little or no use in the treatment for these conditions; something, still a secret, is wanting, possibly the co-operation of secretions from other glands or tissues.[1] The extract is called *Antuitrin.*

Posterior Pituitary. The function of this part of the gland is much less obscure than that of the anterior, and Biochemistry has given to Medicine an extract of its substance, *Pituitrin*, which now forms one of the most powerful and effective remedies we possess. An immense amount of work and experiment have been done in testing the effects of the extract on the bodily tissues, and it has been proved to contain at least two active principles. One of these has the power of stimulating the special form of muscle found in the coats

[1] Beneficial results have been obtained in defective growth (Sir W. Langdon-Brown, M.D., 1937).

of the blood vessels, causing their contraction and a rise of blood pressure ; the other has a powerfully stimulating effect on the muscular coats of the bowels, bladder, and womb, and is of great service in Midwifery. The extract must be given by injection under the skin as its effects are destroyed by the digestive juices.

In addition to these activities the Pituitary Gland, either from its anterior or posterior divisions, acts in conjunction with most of the other ductless glands. Over these it exerts a controlling influence ; or by reinforcing or antagonizing their secretions it keeps a proper *balance* of the supplies required by the different organs. This is certainly the case with the sex glands, both during their development and after functional activity is established, and probably also with the adrenals, and the pancreatic islands.

An example of this balance in which the hormones of the adrenal, pituitary and sex glands all take a part, is the distribution and character of the hair of the two sexes, as well as its loss or superabundance. The failure of the appearance of the hoped-for down on the upper lip of the callow youth, or the early onset of baldness in the adult, no less than the incipient beard or moustache which often causes so much anxiety among elderly and otherwise comely matrons, are probably due to a lack or excess of the "hormones" of these glands. The bearded and masculine ladies sometimes to be seen at Fairs (after payment of an extra fee), probably owe their living and have gained their adornment through an excess of adrenal secretion, or a disturbance of its balance.

The part played by the pituitary gland in health forms one of the most intricate problems of modern physiology and Biochemistry ; and its disorders are known to be the cause of several hitherto unexplained errors of development or growth. Difficult as it has already proved to

find out a few of its secrets, sufficient is known to establish it as one of the most essential organs of the body.

The Sex Glands

In addition to the above, extracts from the sexual glands, the testicles and ovaries, including the mammary glands, are now extensively employed to regulate disturbances of their functions. There are several distinct extracts differing in their action which can be isolated from one another, and have proved of the utmost service, especially in certain disorders of women. Here, again, co-ordination with the pituitary gland takes place.

GRAFTING OF GLANDS. The mysterious influence of the "internal" secretions of certain of these glands has been tested in another way; by grafting. For instance, by removing the sex glands in fowls, and substituting for them respectively the glands of the opposite sex, hens will then take on the appearances and characteristics of cocks, and vice versa. In hens the combs and wattles grow bigger, spurs appear on the legs, and they strut and try to crow, and become pugnacious; the cocks, on the other hand, tend to lose the adornments and weapons of their sex, and the desire to fight; their bright colouring fades; they cease to disturb the night, and acquiring domestic habits find a solace in trying to incubate eggs.[1]

Again, glands taken from young animals (e.g. rams) have been grafted into old and useless specimens, and in some cases with astonishing effects in prolonging age and virility; and the same operation has even been performed on the human subject with the celebrated "monkey glands" by the surgeon, Voronoff. The results on the whole have been disappointing; new wine cannot be put into old bottles. It would be an appalling disaster if means were ever found to prolong old age and revive in

[1] F. H. Crew, *Animal Genetics*, p. 204 et seq. (Oliver & Boyd, 1925.)

it the powers of youth. Fortunately, to bring this about a rejuvenescence of *every* organ and function of the body would be necessary, not one alone, and short of the discovery of the Elixir of Life, this is impossible.

In the last few years research in Medicine has been very largely concerned with the study of the ductless glands and their secretions, and the production from them of such powerful and useful remedies as Thyroid extract, Adrenalin, Insulin, and Pituitrin, has aroused great expectations that similar preparations made from other glands would be equally successful.

Consequently extracts of every known gland have been prepared and tried in all kinds of disorders in which a deficiency of a particular internal secretion is suspected. Either given by mouth or injected these extracts have generally proved disappointing. Our knowledge of this very complicated subject is far from complete, and has not justified the commercial "stunt" of preparing and advertising glandular products which are claimed to cure most of the ills that flesh is heir to.

To many who may be considered old fashioned, the amazing discoveries of the functions and importance of these little ductless glands have been somewhat disturbing. The brain and its nerve centres used to be looked upon as the master tissues of the body. They were the seat of the mind, and from them at headquarters issued the impulses that control and regulate all the functions of the other organs. No doubt in a sense they continue to do so, but have lost a little of their former prestige. Like other organs, the nervous tissues, themselves, for their proper development, and functioning, appear to require the stimulus of chemical substances made by the ductless glands. We have seen how, in the case of a Cretin, a mindless idiot can be transformed into a natural individual by taking thyroid extract; how a dull and sluggish

sufferer from myxœdema can regain her wit and alertness by the same means, and how the substance which has this power on both mind and body can be compounded synthetically by the chemist in the laboratory. Are our qualities of mind and character dependent then on chemical substances? our vices and our virtues on the various secretions of these ductless glands? It has been claimed as the result of experiment that mental excitement and fear lead to a discharge of adrenalin into the blood; and that this is probably a protective mechanism to raise the blood pressure, and brace the body to meet the danger; in short, to give courage.

Again, we know that our bodily and mental "make-up" is dependent, to a large extent, on the internal secretions of the sex glands, and becomes altered when puberty is reached, and at the onset of old age. Will the chemists of the future be able to isolate, or manufacture the chemical principles of these and other glands which exercise such a dominating influence? These considerations open up possible, if fanciful, visions of days to come. If fear can be overcome by adrenalin why not other mental states by some other subtle extract! Think what it would mean to have a handy injection for ill-temper and to get the prick before breakfast, and come down smiling; to have another tabloid for the chronic grumbler which would make him see the world through rose-coloured spectacles; and yet another variety for the indolent *malade imaginaire*, who tires out her family with her needs, which would turn her into an unselfish woman interested in something besides the sofa. Such visionary possibilities are unlimited, yet, however disturbing they may be, the progress of Medicine in the immediate future lies in the province of Biochemistry, and from its future discoveries may be expected not only wonderful remedies, but equally wonderful revelations of the mystery of mind and body.

Chapter XIII

CHEMOTHERAPY, INCLUDING SALVARSAN, SULPHONAMIDES, PENICILLIN

In spite of the immense consumption of drugs of all kinds—and patent medicines—to which allusion was made on page 6, no remarkable advances had been made during the first years of the present century in pharmacology.

Various new antiseptics had been introduced such as Acriflavine, Proflavine, Gentian Violet, synthetic products obtained in the manufacture of the aniline dyes from coal tar, and which have special affinities in staining and sometimes destroying certain types of bacteria.

Internal medication was for the most part limited to the well-known old-fashioned drugs, though indeed these were gradually being replaced by the more scientific methods of introducing vaccines and antitoxins directly into the blood or tissues, through the veins, muscles, skin, or even the spinal canal. By these routes the remedy was able to exert its effects directly, by either destroying an infective agent itself—or stimulating the tissues and blood to manufacture the appropriate " antibodies ".

A new era in Medical discovery, directly due to purely *Chemical* researches in the synthesis of hitherto unknown organic compounds, began in the first years of this century, and has already had startling results in many diseases and infections, in Surgery, and Midwifery.

A clumsy nomenclature " Chemotherapy " has unfortunately been adopted to designate this new form of treatment due to Chemical Science, and which in simpler form means " Treatment by Chemicals ".

A very brief outline can only be given of the main land-

marks of this highly technical subject, and its general bearings on Medicine. The story begins with the discovery of the essential cause of Syphilis, a protozoal parasite, the "Spirochæta Pallida," by Schaudinn in 1905.

This organism, which for so long had eluded discovery, is almost transparent and very difficult to stain, and is best seen under the microscope by a special optical arrangement, in which its shape is seen as a blank outline against a dark background (see Fig. *e*, page 90). Then quickly followed (1905) the discovery by Von Wassermann, a pupil of Ehrlich, of a test whereby the presence of Syphilis in the blood can be detected, whether of recent origin, or years after the initial infection. (Von Wassermann reaction.)

The test is a triumph of Biochemistry, highly technical in detail, and was simplified at a later date by Kahn (Kahn test). It is made possible by the presence of an "antibody" in infected blood which reacts differently when contacted with healthy blood or another infected blood.

Syphilis, perhaps the most horrible of all diseases, is supposed to have been introduced into Europe at the time of the discovery of the New World, though this is extremely doubtful. It may attack almost every structure in the body, causing ulcerations, deposits, deformities, destruction, and affecting the internal organs, the blood vessels, the bones, and nervous system.

Its cruel feature is the faculty of possibly remaining in the system for life, and in later years causing diseases like Locomotor Ataxy or General Paralysis of the Insane, and, worst of all, it may be, and frequently is, handed down to the next generation—congenital Syphilis. Until about 1910 the classic treatment of Syphilis was the continued use for months or years of mercury, often in conjunction with iodide of potassium. These remedies certainly had

an effect, and in many cases apparently cured the disease, but they were uncertain, and mercury more especially affected the general nutrition, and often caused serious disorders of the teeth and gums. It was early in the century that the new era of Chemotherapy may be said to have begun with the laborious researches of Paul Ehrlich of Frankfurt (1854–1914)—firstly in regard to the medical uses of various chemical compounds from the aniline dyes, as mentioned above, and later by experimenting with *arsenical* derivatives, suggested perhaps by the well-known use of arsenic in the treatment of obscure blood diseases, like pernicious anæmia, Addison's disease.

With incredible patience Ehrlich set out to discover a remedy from among the many new arsenical compounds he was synthesizing which might kill the Spirochæta Pallida of Syphilis.

It was not until he had tried out no less than six hundred and six new compounds that he at last found one in 1910 which was lethal to parasitic protozoa, among them the parasite of Syphilis.

Chemotherapy

The formidable chemical name of this substance, a compound of arsenic and benzene, is dioxydiamine-arseno-benzene-dihydrochlorida, syn. Arsphenamide—also known as Salvarsan, but generally known as " 606 " to commemorate its hard-won discovery.

It has now been superseded by still other similar derivatives, among them neo-arsphenamide.

This remarkable chemical, when injected direct into a vein is carried to every part of the body, and causes the destruction of the parasite, not apparently by direct action but the formation of a derivative in the blood and tissues. The injections are repeated at intervals in

courses, with intermissions, over a period of one to two years, often in combination with compounds of bismuth, a heavy metal, which like mercury, is also inimical to the Spirochæte.

The essence of success is early treatment. It has been estimated that 95 per cent. of cures can be obtained with early treatment, and up to 60 per cent., even if several weeks have elapsed since the infection. Expectant mothers with Syphilis should be treated before the birth. Treatment centres are now established all over the United Kingdom, and the cure and the eradication of the disease are in the hands of the people, and the victims themselves.

Before the present war, to illustrate the diminution of Syphilis,

In 1920, 42,000 applied at Treatment Centres
" 1933, 21,000 " " " "
Congenital Syphilis in 1917, 2·03 per 1,000 of total births
" " 1933, 0·40 " " "
(Ven. Diseases Act, 1917, Vol. I, 20th edit.)

The Sulphonamides

In 1933 Foerster of Dusseldorf, who was engaged on dye production from the benzene derivatives of coal tar, produced a red dye—*prontosil*—and in 1935 Domagh, who was experimenting on the disinfecting qualities of certain of these dyes, announced that prontosil had a remarkably destructive effect on streptococci and staphylococci in *living* tissues; hardly if at all *in vitro*. Mice, which had been given an otherwise fatal inoculation of these septic germs, recovered quickly, and remained well if injected with prontosil shortly before, or at the same time, or soon after the inoculation.

This startling announcement put on the track many research workers, who confirmed Domagh's experiments on the specific effect of prontosil on the pyogenic (pus-producing) cocci, and it was also found out that this dye—and other closely related chemicals—had specific effects on other infections, e.g. Pneumonia, Cerebro-spinal Meningitis, Gonorrhœa, Erysipelas, Puerperal Fever; and in the last named prontosil was used at Queen Charlotte's Hospital for Women as early as 1936 with good results.

Later on it was found that certain synthetic derivatives of prontosil were of still greater efficiency in controlling these infections. These derivatives, a number of which have been produced, contain sulphur and nitrogen (amines) in their molecules and are generally known as the "Sulphonamides," but mention here can only be made of two which are most frequently employed, viz. Sulphanilamide and Sulphapyridine.

Chemotherapy

How do these substances act on specific microbes, and arrest their deadly activities? They are not directly "bactericidal" by contact, either in or outside the body and yet they act by arresting at once the growth of the microbe in *living* tissues and blood, and it is supposed that they alter the essential substances in the living tissues on which the specific germs depend for their growth and multiplication, viz. they are "bacteriostatic". Moreover, they do not stimulate the body to produce "antibodies" as do the vaccines, and in the presence of large suppurating wounds, and accumulations of pus or dead tissues their action is neutralized; locally they act best by stopping further infection of cleaned or partially cleaned surfaces and tissues, and in general blood poisoning.

Sulphanilamide may give rise to ill-effects unless dosage and regulation of administration are carefully observed; headache, vomiting, depression, or more seriously jaundice, lividity, and blood disturbances, though very few fatalities have been recorded considering its widespread use. It can be used locally as a powder, or cream, or lotion, and is extensively employed in these forms for wounds, whether war or accidental, and for burns.

In many coccus infections hitherto unamenable or resistant to the usual treatment its immediate effect is almost dramatic—erysipelas, cellulitis, sepsis, acute ear suppuration, cerebro-spinal meningitis, gonorrhœa, and other coccus infections are arrested, and convalescence begins at once instead of following a long illness. Perhaps the most startling of all is the picture of the pneumonia patient nowadays. In this fell and fatal infection, responsible in the past for so many deaths in young and old—so acute in onset, so rapid in course for well or ill, the discovery of the Sulphonamides has brought about a dramatic change of outlook.

Not long after the discovery of sulphanilamide, another similar product was introduced by Wright—and was elaborated by May & Baker, the great manufacturing chemists, after prolonged chemical therapeutic trials to the number of six hundred and ninety-three—(1939). The substance is Sulphapyridine, and is popularly known as M. & B. 693. This product has a specific effect on pneumococcal infections over which sulphanilamide has but little power.

To anyone accustomed to the former picture of acute pneumonia—the sudden rigor, the high fever, the laboured breathing, the urgent distress, the literal fight for life over a period of six to ten days, and then the sudden drop in the temperature chart as the crisis came, and convalescence began at once; or the other alternative, the

growing exhaustion, delirium, lividity, inability to take nourishment, the faltering pulse, the labouring heart, precursors of the end—the astonishing change for the better after the administration within forty-eight hours of a few tablets of M. & B. 693, seems almost miraculous, and no less a triumph than David's little pebble on Goliath's mighty brow.

The acutely ill patient on the second or third day greets the doctor with a smile, asks for food, and when he is likely to get up—his temperature is dropping already, and distress has flown! Is there nothing of Romance in Medicine?—in the labours of the quest?—in the triumph of attainment?—in the saving of thousands of lives?

Reliable statistics of the fall in the total death rates in pneumonia since the advent of Sulphapyridine are not yet available—the war has introduced many complicated factors—but at Glasgow some endeavour has been made to compare the 1939–41 mortality of cases *notified* with those of the previous ten years, and these figures show a drop of one-third (*B.M.J.*, Dec., 1943).

Penicillin

The discovery of Penicillin should certainly rank among the "Fairy Tales of Science".

This powerful and invaluable agent in stopping the growth of certain microbes which poison wounds and infect the system is extracted from a mould (Penicillium Notatum) which as a class have hitherto been numbered among the nuisances of life, like the moth and rust which corrupt, but which we may now perhaps regard in the same light as our fathers did the toad which, "ugly and venomous, wears yet a precious jewel in the head".

Moulds lurk in damp corners, spoil our preserves, and are a sign of decay or death wherever they appear, and,

moreover, have a special liking for the nutrient media on which the bacteriologist sows the germs he is cultivating for experiment, and spoils much of his work by spreading over his young colonies.

And here it is that a simple observation—quite after the style of Pasteur—brought about the discovery. Professor Fleming in 1929 noticed that a mould (Notatum), which appeared as an accidental contamination in a bacterial culture plate, was surrounded on the plate by an area where the colonies growing freely elsewhere died off and refused to develop. He then grew the mould pure in broth, and found that the *filtrate* was very active in inhibiting growth of pyogenic (pus) cocci; the name Penicillin was given to this broth filtrate.

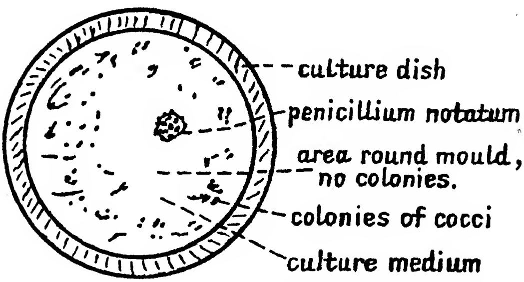


FIG. 26A.

In 1933 Professor Raistrick, London School of Tropical Medicine, devised a special culture medium, synthetically prepared from various chemicals in which the mould flourished and grew rapidly. In 1939 the whole question of the therapeutic uses of penicillin, its efficacy as a bacterio-static agent, its culture, and extraction, and standardization, was taken up by Professor Florey, and coadjutors, of Oxford—and the result of their researches was published in their historic paper in the *Lancet*, August 1941. Extensive experiments on mice were made

to test its power of protection against pyogenic cocci to which mice are very sensitive; the extracted penicillin was found to give complete immunity to the mice even in highly diluted solutions: and in culture media it inhibits coccal growth in dilutions of $\frac{1}{500,000}$. Penicillin itself was found to have no harmful effects whatever on mice or other animals—and this applies equally to human beings.

Moreover, the inhibiting power of penicillin on pyogenic cocci is much greater than that of the Sulphonamides, and its action is not vitiated as in their case by the quantity of microbes present, or accumulation of pus and dead and damaged tissues; hence it is of much greater service in suppurating wounds, and established sepsis of later date.

Penicillin is rapidly absorbed, and excreted by the kidneys, and when used locally frequent irrigation is necessary through rubber tubes or other means to the wounded surfaces. When given by injection into muscles, or veins for severe cases, or general sepsis, much higher concentrations are necessary, and the demand for more and more of this wonderful product continually increases.

The cultivation of the mould in quantity, in the synthetic culture medium, and the extraction of the pure penicillin from the crude mother liquor, a very complicated and delicate chemical undertaking requiring an elaborate and newly devised plant, is now being taken up by large manufacturing firms, but the demand largely exceeds the supply.

The standardization of penicillin, as established by the Oxford test, is again a most delicate and elaborate concern. Its strength must conform to that coefficient whereby a definite dilution of the pure extract must be inhibitory to a definite lethal dose of Staphylococcus, as tested on animals. When we consider that this substance is the product of a variable mycelial growth, it is easy to see how

inferior or worthless samples might come into supply were it not for an ensured standard of efficacy.

The investigation of the by-products of moulds other than " Notatum " opens up a new field in biochemistry and bacteriology, and of their influence in Medicine.

Already (1944) new anti-bacterial agents for infections other than sepsis have given promise—among others " Patulin "—and very recently a substance produced from moulds " Penatin " has been described (*Nature*, 152, 604, 1943), even more powerful than penicillin. It is claimed that it shows activity in dilutions of $\frac{1}{400,000,000}$ and is effective in anthrax, diphtheria, typhoid and pneumonia, and other microbic infections, but it is too early to feel assurance without further prolonged experiments and confirmations.

When one ponders over these three epoch-making discoveries alone in Chemical and Biochemical Science, in this present war-ridden century, of Salvarsan, Sulphonamides, Penicillin, and considers how they were gained, and the immeasurable benefits they have conferred on mankind, by the toil, skill, patience and knowledge of many explorers on voyages of discovery, surely we may answer, " Yes, there is Romance in Medicine—in the quest, and in the triumph of attainment."

CHAPTER XIV

VITAMINS

OTHER remarkable discoveries during the last twenty-five years, which in their bearings on general nutrition and physique have become of national importance, relate to foods and must also be credited to Biochemistry. Food is not a very romantic subject to write about, but it is probably the most common subject of our thoughts, and for many people is the chief concern of their home life, and one of the most attractive features of their holidays.

It is not necessary here to enter into chemical details. By the end of last century, the essential constituents of the food required by our bodies, both in quality and quantity, were supposed to be well known. So much nitrogenous material (proteins) supplied by meat, fish, and eggs ; so much starch or sugar (carbohydrates) in bread, potatoes, rice, etc. ; fats from butter and suet ; inorganic salt, including phosphates, iodine, iron and other elements found in fruits and vegetables. The respective values (calories) [1] of these constituents for supplying energy and heat, and for the growth and repair of the tissues, had been worked out and it all seemed very complete. It was only necessary to take in so much of each class of food in due proportion and the body would flourish. So far, so good, but this was not the whole story.

[1] From Hutchinson and Mottram, *Food and Nutrition*, 8th edition (Arnold), p. 936.

A calorie = the heat required to raise 1 kilogram of water from 17° C. to 18° C. Average amount of food constituents required daily for adult in work (minimum). Attwater.

Protein.	*Fats.*	*Carbohydrates.*
125 grams.	125 grams.	400 grams to supply 3,315 Calories.

The two tables below show these factors translated into a diet which

In 1912, Professor Gowland Hopkins (President Royal Society, 1930–5) who was working on the chemistry of foods and their values, discovered that young rats, fed abundantly on *artificial* foods which fulfilled all the above requirements, failed in their growth, and their skins and eyes became diseased ; while a like number fed on the same foodstuffs with the addition of a little *fresh* milk, developed in a natural manner. In a similar way puppies fed on artificial foods, and deprived of raw milk had been found to develop rickets. At one time nearly all the lion cubs born at the Zoo and kept in cages, succumbed to

would afford *approximately* the required *minimum* with the cheapest price at which it could be obtained (1937).

		Proteins.	Fats.	Carbo-hydrates.	Calories.	Cost.
1 Bread	1½ lb.	49	1·3	327·3	1,518	3¼d.
2 Beef	10 oz.	41·7	55·3	—	685	10d.
3 Potatoes	½ lb.	4·1	0·1	42·6	193	¾d.
4 Margarine	2 oz.	0·1	48·1	—	447	1d.
5 Jam	2 oz.	0·2	—	39·3	162	1d.
Total	—	95·1	104·8	409·2	3,005	1s. 4d.

		Proteins.	Fats.	Carbo-hydrates.	Calories.	Cost.
1 Bread	1½ lb.	49·0	1·3	327·3	1,518	3¼d.
2 Cheese	6 oz.	43·7	59·6	5·3	754	3d.
3 Butter	2 oz.	0·1	47·1	—	438	2d.
4 Milk	10 oz.	9·4	10·2	13·6	159	1½d.
5 Watercress	2 oz.	0·8	0·2	2·4	15	1d.
Total	—	103·0	118·4	348·6	2,884	10¾d.

Life could be sustained and moderate labour performed on either of these diets which would also supply the necessary vitamins. Eggs ; fish (herring) or other meats might replace (2) and a fresh vegetable or fruit (5).

Mrs May Mellanby, Sc.D., after an elaborate research,[1] has proved that vitamin D also influences the proper development and shape of the teeth, and that decay is more liable to occur in those that are irregular or badly formed.

The dose of the pure *isolated* vitamins, *Carotene* or *Calciferol*, required to "activate" food is exceedingly small. About $\frac{1}{2,000,000}$ of a gramme (15·4 grains) daily of *Carotene* was found sufficient to keep a rat in health, and it has been calculated that 1 ounce of pure *Calciferol* daily to prevent rickets would be a sufficient ration for 1,000,000 children.

Vitamin B

In the Far East—India, China, Malay—a large number of the lower caste natives and coolies live almost exclusively on rice; and for economic or other reasons preference is often given to "polished" rice (rice freed from the surrounding husk). Rice until lately was also the stock ration of the Japanese Army and Navy. To a European it appears incredible that the endurance and capacity for work of the labourers, and the proved fighting qualities of the Japanese soldiers and sailors, could be sustained on such a one-sided diet; and yet such was the case.

Nevertheless, there are certain diseases in these parts of the world which are hardly ever met with elsewhere. In one of these called beri-beri, the nerves become inflamed and painful, leading not infrequently to paralysis and a fatal ending, and this disorder was very prevalent among coolies, and accounted for a great deal of the sickness in the Japanese fighting services.

It was suggested as far back as 1882–6 that an exclusive

[1] Medical Research Council—Special Report, 140, 1929.

diet of polished rice was the origin of the trouble, since a similar paralysis of the legs had been observed in fowls fed entirely on this foodstuff. It was found that a more all-round diet, or even one of *polished* rice, *if husks were added*, was all that was necessary as a preventive, or remedy, for the disorder both in poultry and patients. Previously a bacterial origin had been suspected. The essential factor which exists in the husks of rice, beans, and other cereals, and prevents beri-beri has been found, and is called Vitamin Water Soluble B 1.

Another serious " deficiency " disease occurring among poverty-stricken populations who live chiefly on *maize* is called " Pellagra ". It is found in Italy, South-Eastern Europe, West Indies, and the Southern United States. In the latter country in 1917 it caused 170,000 deaths, and after many experiments it was found to be curable by adding Meat, Milk, Greens, or Yeast to the diet. The vitamin has not been isolated but is known to exist and is called B 2.

Vitamin C

A disease which for centuries had been recognized as due either to tainted food, or to some deficiency in diet, was called the scurvy. It was the scourge of seamen of all countries, and responsible for many of the disasters which attended the long voyages of the early navigators and explorers. Until the middle of the last century it was of common occurrence in the Royal Navy and Merchant Service. It is a horrible disease ; the impoverished blood escapes from the veins, and causes swellings in all parts of the body ; the gums become swollen, and the teeth drop out ; breathing becomes difficult, and extreme exhaustion is often the precursor of a miserable death. Every schoolboy fond of books of

adventure has come across tales of the sea which tell of scurvy; and it is not necessary to enlarge on its terrors or ravages. On these long voyages the diet consisted mainly of pickled pork (salted meat) and ship biscuit ("hard tack"), and the crew were more inclined to attribute the disorder to some taint or foulness in those articles, rather than to a *deficiency* of any kind.

In 1740–4 the celebrated voyage of Admiral George Anson to the Pacific affords a notable example of the disasters caused by scurvy. Starting with six ships, the crews eventually became so reduced in numbers that they had to be collected on to his own flagship, the *Centurion*, which was the only one after four years to complete the voyage. It was the celebrated Captain James Cook, R.N., who, in his three voyages of discovery between 1768–79, found out the way to defeat scurvy. He was a large-hearted man and though a strict master, treated his men well. On his voyages he would, instead of passing by, land at every possible place, and send men to gather fruits or green stuff, or barter with the natives for fresh food of every description. In his second voyage to the South Pacific in the *Resolution* (1772–5) he lost only one man out of 118, in 1,000 days. The success of Captain Cook's methods led the Admiralty in 1795 to provide for the issue of limejuice on all His Majesty's ships, though it was not until 1865 that this regulation was made compulsory for the Merchant Service by the Board of Trade. Since that time scurvy at sea has become rare on British ships; and perhaps the term "Limejuicer" is no longer used, as it was at first, by foreign seamen to designate a vessel flying the Union Jack—a term which, under the guise of contempt, probably concealed no little envy.

Scurvy, however, may occur elsewhere than on board a ship. In former days it was not uncommon in prisons,

and is occasionally met with at the present time in infants and young children who are fed *exclusively* on sterilized, or tinned foods, such as condensed milk. In these cases it is generally associated with rickets.

The anti-scurvy vitamin was isolated from Paprik (Hungarian pepper plant) in 1934, and is identical with a known organic compound, *ascorbic acid.* A few grains of this substance would suffice to keep a large ship's company free from scurvy on a long voyage, and would have saved from suffering or death some 7,500 British, besides Indian soldiers, who were stricken with scurvy at the siege of Kut, and elsewhere in Mesopotamia during the Great War.[1]

Allusion was made on page 178 to the effect of sunlight on the starving children of Vienna after the Great War, and how it could act as a substitute for the necessary vitamins in food. Vitamins in reality are bottled up sun rays, and the complicated chemical compounds of which they consist are built up by the energy of the invisible ultra-violet rays of the sun acting on certain substances found in the structures of animals and plants. Moreover, the influence of these rays extends to non-living substances. Sterilization of food substances, by cooking or boiling, destroys most of the vitamin content, but this can be restored by their subsequent exposure to ultra-violet rays from an arc lamp—a process now largely used in commerce and known as "irradiation". Similarly, substances such as olive oil, or margarine, which contain no vitamins, can be "activated" by irradiation and made vitamin "effective", though to a lesser degree than exists in the natural oils of the cod, or the fats in cream and butter.

The chief source of vitamins is found in plants, which by means of their *chlorophyl* (green colouring matter) store

[1] Aykroyd, *Vitamins*, 2nd edition, p. 88. (Heinemann.)

up the sun rays. Animals gain their vitamins partly by eating plants, such as grass, and partly by the direct action of the sun on their skin; carnivorous animals (tigers, lions, etc.) get theirs by eating animals which eat plants, and so on like the House that Jack built. How comes it, then, that a *fish* oil from cod and halibut is so rich in Vitamins A and D? Fish are supposed to obtain their supply of vitamins from the minute algæ and plant life in which the sea abounds. The smaller creatures live on these foods, and the larger on the smaller in an ascending scale, until we get to cod and halibut living on squids, and sharks living on cod and halibut, and each one in turn derives its vitamin far away back from the sun rays diffused in the water and stored up in its plant life.[1]

The subject of vitamins is one on which it is easy to get confused and perhaps will be more readily grasped by a glance at the table (page 177), which sets forth the class, source, function, associated disorder, isolation.

Food values and the nature and influence of vitamins will probably be considered by many a very dull subject. Nevertheless, the well-being and stamina of the nation's life, especially in regard to its children, depends very much on proper nourishment, and the discovery of vitamins must rank as a definite landmark in Medical progress. Now that we know that certain substances to be found in certain foodstuffs are essential for proper growth, the formation of bone, and the avoidance of "deficiency" diseases such as rickets, and scurvy—as well as for the greater resistance which good nutrition affords against many other disorders, notably infectious diseases—it is of vital importance that these classes of food should be within the reach of everybody.

[1] "Big fleas have little fleas, upon their backs to bite 'em,
And little fleas have lesser fleas, and so *ad infinitum*."

Fresh milk is by far the most important—and in infancy, mother's milk. Milk contains practically all the necessary vitamins except, perhaps, C, which can easily be supplied by a little orange or other fruit juice. Butter (not margarine), dripping, suet, eggs, cheese, come next in importance. Milk may convey many diseases—for example Tubercle, Typhoid, and other infections which could be eliminated by pasteurization—and the guaranteed grades are expensive; so, too, are fresh butter and eggs. What, then is to be done? These articles must either be cheapened, or incomes increased to buy them at their present prices. But here another factor comes in. Tinned foods, and all sorts of ready-made stuffs are nowadays relatively cheaper than the essential ones, and save the trouble of preparation. Patent foods of all varieties save the trouble of "nursing" babies. Unless the nation becomes more alive to food values and less "tin minded", and housewives return to their cooking, larger incomes and higher wages will only create a demand for still more elaborate ready-made preparations, cunningly contrived to please the palate, but of little value for nutrition. Moreover, the pure isolated Vitamins, though useful as medicines in special circumstances, cannot take the place of the parent foodstuffs in which they are found, and which provide the food and fuel by which the body is sustained.

There should be little fear of a vitamin deficiency in any household, however poor, if milk, and fresh vegetables or fruit are brought within its reach. The tendency in poor families is to purchase the cheaper cereal foodstuffs, and neglect the essential fats, any surplus being spent on meat, or a glass of beer, neither of which though appetizing, is so necessary.

The improvement of national physique and capability largely depends on proper food as well as on physical and

mental training. This was tersely expressed in a recent speech by Lord Horder in the Upper House, when he reminded their Lordships that a " Nation progresses on its stomach ".

Chapter XV

BLOOD TRANSFUSION

Among new methods of treatment which have become generally adopted within the last twenty years there is probably none that appeals more to popular imagination than blood transfusion.

Although this comparatively simple operation is now a daily occurrence, a tinge of glamour still surrounds it, and the person (donor) who gives up some of his or her blood to save another. Needless to say, no donor nowadays considers that there is anything heroic in this small sacrifice which hardly entails more in its effects than a loss of time. It was far otherwise a few years ago. The rare occurrence of a blood transfusion was eagerly seized upon by the press, and all the details given to the world with the names of the gallant donor—and the "snatched from death" recipient.

As late as 1917 in the Great War, when transfusion came into common use in Casualty Clearing Stations at the front, the fortunate giver of blood was deemed worthy of twenty-four hours or more off duty, a liberal ration of stout or port-wine, and a fortnight's leave of absence to "Blighty"! Needless to say, there was no lack of candidates, and there must have been many curses among those whose blood was of a "group" (a term I shall explain later on), which was incompatible with that of their wounded comrade in arms.

I have called blood transfusion a *new* method of treatment—but more properly it should be termed "*revived*", for in 1666 it had been suggested by Sir Christopher Wren, distinguished in philosophy and science as well as

in architecture, and the first operation of this nature on a human subject was performed in 1667 by Jean Denys, physician to Louis XIV of France.

Mr Geoffrey Keynes gives many interesting details of the early days of transfusion in his book on the subject.[1] The discovery of the circulation of the blood in 1628 by Dr William Harvey gave an immense impetus to research, and one of the earliest enquiries of the Royal Society, founded by Charles II in 1662, was directed to the effects following the transfusion of the blood of one animal into the circulation of another of the same or of a different species.

Samuel Pepys, the diarist, whose insatiable curiosity made him acquainted with all the affairs of the town, relates in his Diary, November 14th, 1667:

> To the Pope's Head, and Dr Croone. Dr Croone told me, that, at the meeting at Gresham College to-night, there was a pretty experiment of the blood of one dog let out, till he died, into the body of another on one side, while all his own run out on the other side. The first died upon the place, and the other did very well, and likely to do well. This did give occasion to many pretty wishes, as of the blood of a Quaker to be let into an Archbishop, and such like; but, as Dr Croone says, may, if it takes, be of mighty use to man's health, for the mending of bad blood by borrowing from a better body.

Again, on November 21st, 1667, he relates:

> With Creed to a tavern, where Dean Wilkins and others: and a good discourse: among the rest of a man that is a little frantic, that hath been a kind of minister, that is poor and a debauched man, that the College (the Royal Society) have hired for 20s. to have some of the blood of a sheep let into his body, and it is to be done on Saturday next. They purpose to let in about twelve ounces; which they

[1] *Blood Transfusion*, by Geoffrey Keynes, F.R.C.S. (Hodder & Stoughton, 1922.)

> compute, is what will be let in in a minute's time by the watch.

This experiment was carried out on "the poor and debauched man", Arthur Coga, at Arundel House, on November 23rd, 1667, by Dr Richard Lower. One week later, Pepys met Mr Coga at "Cary House" a place of entertainment in the Strand, and continues his narrative:

> I was pleased to see the person who had his blood taken out. He speaks well, and did this day give the Society a relation thereof in Latin, saying that he finds himself much better since, and as a new man, but he is cracked a little in his head, though he speaks very reasonably and very well. He had but 20s. for his suffering of it, and is to have the same again tried upon him: the first sound man that ever had it tried on him in England, and but one that we hear of in France.

With Pepys' comment that the subject of this experiment was "cracked a little in his head" most people would agree, for Mr Keynes, quoting from Birch's *History of the Royal Society* (1756, II, p. 216), tells us that Coga, when asked *why he had chosen the blood of a sheep for mixture with his own, replied in Latin*: "Sanguis Ovis, symbolicam quandam facultatem habet cum sanguine Christi, quia Christus est agnus Dei." ("The blood of a sheep has a certain symbolical association with the blood of Christ because Christ is the lamb of God.")

It is needless to describe the history of transfusion during the next 150 years beyond saying that the operation fell into disrepute, not only on account of the difficulties met with from the clotting of the blood in the tubes used in the transmission (for which no remedy could be found), but more particularly from the alarming symptoms, and not infrequent deaths, which took place from the introduction of the blood of one animal, or one human being into the circulation of another.

It was not until a greater knowledge of the chemistry of the blood had been gained in the early years of the present century that an explanation of these former disasters was afforded, and scientific precautions discovered to render the operation safe. The explanation was given in 1901 by the discovery of Shattock, an English pathologist, of certain substances, in both the corpuscles and fluid of the blood (serum), that possess the quality, when introduced into the circulation, of coagulating and destroying the corresponding corpuscles and serum of a differing species. In other words, the blood of one animal is incompatible in the circulation with that of another species, because it contains specific substances which react against a strange or foreign blood. These substances are called agglutinins (coagulators)—precipitins (separators)—hæmolysins (dissolvers), and they resemble the "antibodies" in the blood which, as we have seen, confer immunity against disease germs and their poisons. The reactions of these bodies, and their effects, can be demonstrated by appropriate methods in the test tube or by the microscope.

In the old methods of transfusions from animals to man, violent reactions, such as collapse, the passage of blood in the urine, and sometimes sudden death took place. Nor were these untoward effects confined to differing species; the direct transfusion of blood between two human subjects was not infrequently followed at once by alarming symptoms and sometimes by death.

An explanation of the incompatibilities of human blood was discovered by Landsteiner in 1897, confirmed by Jansky 1907, and Moss in 1910, who classified them into four different groups. Each of these groups has its own special agglutinins in its serum, or precipitins in its corpuscles, which coagulate or injure the blood of certain of the other groups, but are compatible with its own

group. The transfusion of two incompatible bloods may give rise immediately to heart failure, and collapse, and even death. In modern practice before a transfusion takes place, the particular group of both donor and recipient is ascertained by a comparatively simple test on a microscope slide, and the presence or absence of danger in the mixing of the bloods can then be determined.

The four groups were classified by Moss as

	4%	43%	8%	45%
Group	I	II	III	IV

but under more recent International nomenclature are now known as

Group	AB.	A.	B.	O.

Each group differs in its capacity for *giving* blood to another group as a *donor*, or being able to *receive* blood from another group as a *recipient*.

This will be better understood by reference to a table

Donors					Recipients				
	AB.	A.	B.	O.		AB.	A.	B.	O.
	May give to					May receive from			
AB . .	+	+	+	+	AB . .	+	–	–	–
A . .	–	+	–	+	A . . .	+	+	–	–
B . .	–	–	+	+	B . . .	+	–	+	–
O . .	–	–	–	+	O . . .	+	+	+	+

where + represents compatibility, and – incompatibility.
O group is known as the Universal Donor.
AB group as the Universal Recipient.

In practice corresponding groups should always be used if possible—viz. donor and recipient should belong to the same group. This invaluable discovery, together with great improvements in the technique and simplification of the operation (which now involves only a painless prick of a needle to recipient and donor), has re-estab-

lished blood transfusion as one of the most successful and striking developments of Medicine. Moreover, direct and immediate transfusion from donor to recipient is no longer necessary. The donor's contribution can be withdrawn, and coagulation prevented by mixing the blood with a small percentage of citrate of soda, and in this way it can be stored and kept aseptic for three weeks if not required on the spot.

Transfusion direct from donor to recipient is now seldom employed. Donors give their contributions at centres which have been established all over the kingdom; the blood is carefully grouped, and citrated and stored at hospitals and centres in "blood banks", on which calls can be made by other hospitals, or doctors within the regional districts of the Emergency Transfusion Service, which was started by the Ministry of Health in 1935 in conjunction with the British Red Cross Society.

The blood banks can now be kept stocked with blood of all groups, and at each donation a sample is taken for checking the group, and tested by the Wassermann reaction for the detection of syphilis.

If the blood is not used in two weeks the plasma (fluid part) can be drawn off under sterile conditions, and sent to special centres for bacterial filtering and drying.

Plasma, the essential fluid nutrient medium of blood (distinct from the corpuscles, the oxygen carriers), is almost as efficient as "whole" blood, especially in shock and other emergencies, and has a great advantage in the absence of clotting, and also that it is compatible with the blood of any of the four groups.

When dried it will keep indefinitely at widely differing temperatures—it can be placed in standardized bottles, redissolved in sterile distilled water before use; and can thus be kept handy for Air Raid Casualties, or sent overseas for use by the Services. To give an example of the

organization and activity, and of the demands made on a medium-size Transfusion Service, here are some figures from Oxford (Radcliffe Infirmary), 1943 :

Hospital banks received 2,740 bottles of blood.

1,270 bottles used to transfuse 475 patients.

416 bottles sent for transfusion to outlying hospitals.

Rest of blood used for making dry plasma, of which 225 bottles were used in the hospital.

In 1942 the Regional Blood Transfusion Services had on their panels 861,000 volunteers.

Number bled 370,000.

294,000 pints made into plasma.

52,000 bottles of blood products sent to the Services.

The Naval, Military and Air Services have their own centres in collaboration with the civilian, in order to acquire large stocks of dried plasma to send overseas and in the war zones made available by air, ship, car or rail for saving lives from the front line to the base hospital.

In addition to its uses both before and after severe operations, or for shock and hæmorrhage in war or accident wounds, and in midwifery, transfusion is now frequently employed as a remedial or restorative measure in many " medical " diseases, especially the anæmias and other disorders attended by lowered blood values. Performed at intervals, a patient who otherwise might have succumbed, may be kept going until natural recovery, or medical treatment has had time to take effect.

In the whole range of surgical or medical treatment there is nothing quite so dramatic and wellnigh miraculous as the effect of transfusion on an apparently hopeless case at the point of death from loss of blood.

The Great War afforded numberless opportunities for the use of transfusion, but it did not become a common

practice until 1917, after the arrival of the American surgeons with a more highly developed technique, which was at the same time simpler in application. A short account of my own experiences in 1918 as a civilian surgeon attached to a Casualty Clearing Station on the Somme, will bear this out.

You must picture, at one part of the camp in a field, several large marquees set up side by side on the bare grass. These were known as: (1) Reception, (2) Pre-operation, (3) Resuscitation, (4) Operation, (5) Dressing, (6) Removal, (7) Hospital. A marquee would contain about twenty to thirty beds, or three or four times that number of stretchers. It is only necessary here to deal with (3) the Resuscitation Marquee, or as it was called, "Resuss".

"Resuss" was a dreadful place. Here were sent the shocked and collapsed cases—alive—but not able in their present condition to stand any operation or manipulative interference, or the journey by hospital-train to the base. They were put to bed, and warmed up by hot air led in from a stove at the foot. They were mostly deadly white and cold, with hardly perceptible pulses, conscious, but strangely quiet and composed, and beyond feeling the pain of their wounds. Most of them did not appear anxious or concerned; a few were restless or delirious. Many of these cases had been lying in "No man's land" for twenty-four or forty-eight hours and were suffering from *general* shock to the whole system—from injury, cold and exposure, as well as from loss of blood.

In the former, transfusion might or might not bring them round, according to the degree of loss of vital power. In the latter—shock due to loss of blood alone—the effect of transfusion of 1 to 1½ pints of blood from a "compatible" donor was often miraculous.

I have seen men looking like corpses on admission,

blanched and collapsed to an extreme degree, pulseless and with only the faintest perceptible breathing, sitting up in bed within two hours of transfusion, puffing at a "fag", and exchanging jokes before they went to the operating table.

Apart from these dramatic effects in cases of hæmorrhage and in collapse from wounds and accidents in warfare or civil life, transfusion is now used in the treatment of many "medical diseases" where the blood is impoverished, or when an internal hæmorrhage has occurred. Its value as an emergency treatment consists in the filling of the gap before natural recovery can take place, and, paradoxical as it may seem, the addition of transfused blood to one who is already bleeding helps to stop instead of adding to the loss. This is probably brought about by the fresh supply of substances in the transfused blood which favour coagulation, and block the mouths of bleeding vessels.

How, it may be asked, is this demand for life-giving blood met, now that transfusion is almost a daily occurrence in large hospitals, and is often needed in private practice? The answer provides one of the most refreshing evidences of altruism for those who take a rather gloomy and depressing view of society. For incomprehensible as human nature is, man's readiness to shed blood (which apparently has not diminished as civilization has advanced) to further a cause, has found a counterpart in his willingness to give his blood to save a friend in need; and not only a friend, but more often a complete stranger! Any healthy person above eighteen, who wishes to render personal service to his fellow men, can find an opportunity with very little sacrifice by joining the Regional Panel of his district for blood transfusion.

The following data gathered from the Report of the Blood Transfusion Service of the British Red Cross

Society for 1936, and kindly supplied by Mr P. L. Oliver, the Hon. Secretary and Founder of the Service, will give some idea of its immense value to the community.

The foundations of the present Service were laid in 1921, and must be credited to the Camberwell Division of the British Red Cross Society, which received a request and supplied a donor in an emergency case. A supply of donors, recruited largely from the Rover Scouts, was then organized and the Service was carried on entirely by the Division until 1925. In that year as many as 428 transfusions were supplied by the members of the local organization. Owing to the increasing demand, as the value of transfusion in a number of diseases as well as in emergencies was realized, the Headquarters of the B.R.C.S. took over the Service in 1925, and its activities have increased steadily year by year.

The donors were supplied by:

Rover Scouts	603
Toc H.	189
Ladies	483
St. John Ambulance / British Legion / Unattached	1,103
	2,378
Record number of calls in one day	34
Number of hospitals supplied	181

Among other facts it is interesting to learn from the report that no donor unless he desires is called for service a second time, but the record of such additional donations has been reached by two members who have given their blood over sixty times!

It is interesting to compare these figures (1936) with the statistics for 1942–3 given on page 192, in order to

gain some idea of the demands for transfusion nowadays, and how they are met by the Regional Services.

The general opinion of donors is to stress the tonic value of blood donation ; they say they feel better afterwards ; but no donor is advised to serve again within three months. One patient in a hospital, suffering from a special form of anæmia, was kept alive between 1925–36 by means of no less than 300 transfusions of blood !

The discoveries in the chemistry of the blood, which have led to the re-establishment of blood transfusion, may therefore justly be estimated as one of the landmarks of medical progress in the twentieth century.

Chapter XVI

PHYSICAL SCIENCE AND MEDICINE

Every branch of the Physical Sciences—Heat, Light, Sound, Electricity, Magnetism—has made important contributions to Medical knowledge and the treatment of disease in recent years. The most valuable have arisen from discoveries made in connection with Light rays, X-rays, and Radium.

Light

Of all the ancient religions, Sun worship is the most easily comprehended, and even at the present day the beaches of our seaside resorts in the summer are dedicated to the performance of a ritual, with or without vestments, which, however much it is now wanting in spiritual feeling, bears witness to a form of adoration. Nor is the adoration without reason. The Sun, though a fierce tyrant in hot climates, is our best friend, the source of energy in all Nature, and in addition to its light and warmth brings a sense of well-being and happiness into our lives which is wanting on dull and depressing days. We take all this for granted, and as long as we can enjoy the sun, hardly care how it works, though Science has discovered many of its secrets, and Medicine in recent years has turned them to great account in the treatment of disease.

Since this chapter will deal with " Rays " of different kinds and their use in Medical treatment, a few elementary facts may make the following pages more interesting and intelligible.

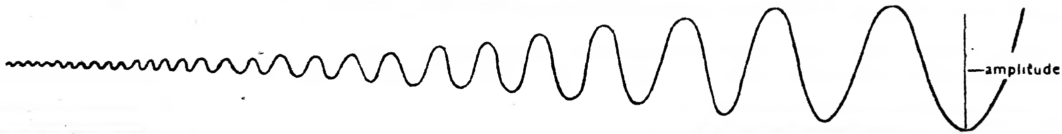
Matter or substance of every kind exists in the form of

Solids, Liquids, or Gases. The substance may consist of the *atoms* of a primary *element* only—for example, Lead, Mercury, Hydrogen—or a *combination* of the atoms of primary elements (molecules) forming a compound substance like Wood, Water, or Coal Gas. The atom of an element was at one time thought to represent its smallest possible unit, unchangeable, and indivisible. We now know that it is made up of electrical particles in motion, one or more negatively-charged particles called *electrons*, revolving round one or more central and positively-charged *protons* in very much the same way as the planets in their respective orbits revolve round the sun.

We do not know exactly what Electricity is and can only conceive of it by its effects, but Science has proved that Matter, in the last resort, instead of ending in atoms, is resolved into electrical particles endowed with energy and motion. Heat causes expansion, and in the unimaginable temperature of the sun, even the protons and electrons of atoms may become violently torn from their orbits, and fly off from one another into space or come into collision with others belonging to another atom. The violent displacement of electrons from their orbits starts *waves of energy* which are transmitted through space—just as a stone thrown into a pond starts a wave we can see, or a hard tap of a hammer on an iron bar will cause a vibration which can be felt at the far end. These waves of energy are called *rays*, and everyone is familiar with the term as applied to Wireless or Hertzian rays, Heat rays, Light rays, Chemical or Photographic rays, X-rays, and lastly Radium rays, and Cosmic rays. All these "rays" are due to waves of energy transmitted through space, but their effect varies with their respective lengths (the distance between each wave), amplitude (height), and frequency (up and down movement of vibration).

RANGE OF ELECTROMAGNETIC WAVES

All waves travel at rate of 186,000 miles per second



Cosmic, Radium $\gamma\beta\alpha$	X-rays hard soft	Ultra-Violet	Visible Light	Infra-Red	Hertzian Waves Short	Hertzian Waves Long, used in Wireless
Emitted when atomic matter disintegrates ×	Emitted by sudden stoppage of fast moving electron	Chemical		Heat	Spark gap discharge	Converted into alternating current of electricity by oscillating valve
cm j0000	000012 wave length			cm j00006 w	ave length	Wave length average 21.470 centimetres ×
× 250000000000	00000000—frequency per second	750b		—375 bil fre	lions quency per second	Frequency do j1 000000 to 500,000 centimetres for B.B.C. per second ×

All rays or waves travel in vacuo at the same velocity as light (186,000 miles per second), but, of course, the smaller ones have to go up and down much faster than the large ones, in order to travel over the same distance in the same time.

Our bodily senses are adapted to perceive only a very small proportion of these rays—Light and Heat. Outside

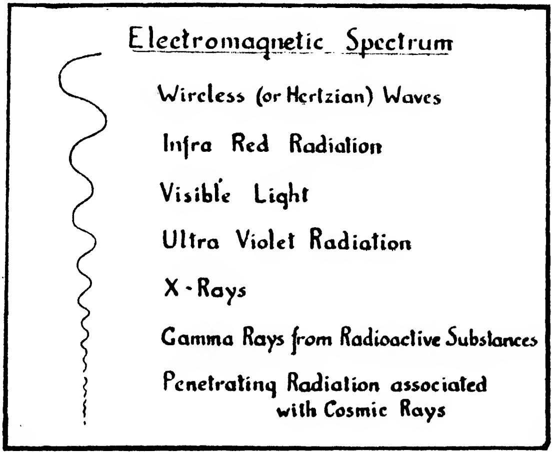


FIG. 27. DIAGRAMMATIC SCALE OF RAYS
(By courtesy of Professor Hopwood, St Bartholomew's Medical College)

this limited range the far greater number can only be detected by more delicate instruments than our eyes and nerves.

The range and relation of these rays to one another are more easily grasped in a diagram, which also shows how they are produced and manifested. The diagram of the waves is, of course, not drawn to scale ; this would be impossible with 250 metres as the average wireless wave length down to one billionth of a centimetre in the case of a gamma ray of radium.

On the left half of the diagram are the Light rays, and their neighbours—the X-rays and the Radium rays—all of which have now been enlisted in the service of Medicine. We will first deal with Light.

Sunlight

White Light or Sunlight is made up of rays of differing lengths and frequency, and by refraction through a prism they can be displayed in due order as the colours of the spectrum, Red, Orange, Yellow, Green, Blue, Indigo, Violet. The space that these *visible* rays occupy in the total range of Electromagnetic waves is the equivalent of hardly more than a foot in a long stretch of miles. Immediately adjoining the Red end of the visible spectrum lies the infra-red territory, where the rays, though invisible, produce heat ; and beyond the violet end are the ultra-violet rays, also invisible, which are known by their chemical effects in photography.

The vast importance of the heat and light rays of the sun require no comment, but it is only within the last fifty years that the chemical significance of the violet and ultra-violet rays has been fully appreciated and turned to account in medical treatment.

The effect of the sun rays as a whole on the body is exerted in many ways. The red and infra-red rays warm the skin, and increase its supply of blood ; more penetrating than the violet rays they may be harmful if the sun is powerful and exposure too prolonged, and lead to reddening or blistering of the skin, or the more serious consequences of Sun or Heat Stroke. They are used artificially in the treatment of neuritis, and for stiffness of muscles and joints after strains or for adhesions left as the result of inflammations. The familiar bronzing of the skin, or formation of freckles, by the deposit of pig-

ment is a protective effort of the body to guard against these mishaps. In coloured races this has become hereditary and babies are born black or brown. Freckles, as we know, are not welcomed by sun bathers for whom the highest standard of beauty is a shade of bronze that reproduces as nearly as possible the natural colouring of a negro.

It has also been proved that the direct rays of the sun arrest the growth or destroy many varieties of bacteria, the majority of which flourish best in the dark ; long standing wounds and ulcers have also been healed by free exposure to sunlight. Most important of all is the stimulus given to cell growth and activity, through the action of the violet and ultra-violet chemical rays. One result, as we have seen, is the production of Vitamins, which we obtain not only from foodstuffs, but also by the direct action of the sun on certain substances found in the skin and tissues. In Chemistry, these substances are known as " Sterols ", and one of them—" Ergosterol "—is easily converted by the chemical rays into Vitamin D. It is so called because it was first found in a fungus—Ergot—which grows on rye, and it is now obtained commercially from Yeast in large quantity, and converted into Vitamin D or Calciferol by " irradiation " with the Mercury Vapour lamp.

Unfortunately, the violet and chemical rays of the sun are stopped far more than the red by watery vapour, such as mist or cloud, or by smoke. They are also unable to pass through ordinary window glass, though a special kind, known as Vita-Glass, allows their passage.

In the moist climate of England, about 95 per cent. of the ultra-violet rays are lost to us, and in smoky towns during winter they are almost entirely wanting. In this respect we are less well off then people who live in a sunny and dry climate, such as the Alpine districts, where, more-

over, the sun rays are further reinforced by reflection from the snow.

But human ingenuity overcomes many obstacles. In 1897 Dr Finsen, an Icelander, invented a way by which the sun rays, when needed in Medical treatment, can be imitated or even bettered by artificial means, at any time of the year and in all climates.

Iceland does not enjoy a sunny climate and perhaps for this very reason, Finsen, a young man in delicate health, was naturally attracted to the study of light and warmth and their influence on health. He went to Copenhagen for his medical course, and with a natural gift for original research, along with unlimited patience and mechanical ingenuity, conducted experiments on light and its biological effects, which led to the construction of the celebrated "Finsen lamp".

There is a classical myth which tells how Phaeton, the son of Phœbus, the Sun God, tried to drive the chariot of his father with its horses on its daily course round the world. The drive ended in disaster; the earth caught fire; the sea began to dry up; and Jupiter had to launch one of his thunderbolts and knock Phaeton off his seat. Phaeton had not learnt how to manage or direct the horses of the Sun either as a team or individually. He did not even know their names, though nowadays they would surely be called after the seven colours of the spectrum. Finsen did better than Phaeton. In a series of ingenious experiments he studied the character of the spectrum rays and their effect on the living cells of lowly organized creatures, and on various kinds of microbes. He put butterflies, woodlice and other creatures into a box with a glass lid, the panes of which were the colours of the spectrum, and found that some were more sensitive to violet and others to red light. He found that sunlight killed most of his microbe cultures; and he discovered

methods whereby the violet and ultra-violet rays could be made to penetrate the skin to a greater depth, and act on the deeper tissues. He became convinced that the sun rays generally had a beneficial effect on cell vitality, and more especially that the chemical ones could be employed in obstinate skin diseases which resisted all other forms of treatment. His great discovery was the employment of the intense light of the electric carbon-arc lamp as a substitute for the sun. The powerful heat and light of the carbon-arc forbade its approach to the skin, or the use of ordinary glass lenses, so that it was necessary to filter off all the rays except the cold chemical ones. With the help of quartz lenses, water cooling, violet glass, and a multitude of ingenious devices, he was able at last to construct his wonderful lamp, and concentrate the desirable rays, freed from the danger of burning, on any particular area of the body.

This lamp aroused the curiosity and interest of the whole world, and people flocked to Copenhagen to see it, for with it Finsen was able to heal "Lupus" (Latin, Wolf), a hitherto incurable disease, which eats away the face and skin and causes horrible disfigurement. Among other visitors came King Edward VII and Queen Alexandra, who in 1900 gave one of the lamps, by which hundreds of cases have since been cured, to the London Hospital.

Finsen died in 1904, when he was only forty-three, and further developments of sun and light treatment, in which he was the pioneer, have established it as one of the great landmarks in Medicine. Open-air treatment by sun rays is now widely employed in many diseases, especially in children suffering from tuberculous glands or joints; for rickets; or for general malnutrition.

Immense improvements have been incorporated in the lamps that have taken the place of the original Finsen

apparatus, which, though a model of ingenuity, was very cumbersome.

Mercury Vapour, or Tungsten arc lamps, are now used instead of the carbon variety, and in the most smoky and sunless towns are efficient substitutes for the sun all the

FIG. 28. CHILDREN AND ARC LAMP TREATMENT
(By courtesy of Messrs Newton, Museum Street, W.C.1)

year round. A number of patients arranged round a single lamp can be treated at the same time. Radiant heat, applied in "Light baths," is replacing the old "Turkish" bath; with special apparatus it can be used for the treatment of rheumatism, neuritis and other com-

plaints, and there are few up-to-date hospitals which do not possess a special department for Light treatment.

Perhaps the most dramatic results of Sunlight and open-air treatment are to be found at Special Institutions

FIG. 29. CHILDREN AND SUN TREATMENT AT HAYLING ISLAND
(By courtesy of King Edward's Hospital Fund)

devoted to this purpose. Notable among these in England is the Treloar Hospital for Cripples at Alton in Hampshire, under the management of Sir Henry Gauvain, and in Switzerland at Dr Rolliers' Hospital at Leysin.

Electricity: Magnetism and Heat

The " direct " or constant currents of Electricity are used in many forms of treatment or for Medical or Surgical purposes—e.g. in co-operation with massage in the rehabilitation of muscles or as a general stimulus in electric baths for encouraging imperfect nerve conductivity—in the testing of muscle reactions after paralysis, or for lighting effects in the illumination of internal structures

like the gullet, stomach, or bladder, or for heating purposes as in diathermy, the electric cautery, and knife which both cuts and arrests bleeding simultaneously.

Magnetism, too, is made use of in the extraction of metallic particles of iron from the eye, or skin.

The application of Heat, the oldest perhaps of all treatments, has been greatly improved by the introduction of dry radiant heat baths, for the whole body or individual limbs.

Chapter XVII

RÖNTGEN AND THE DISCOVERY OF X-RAYS

The biggest debt that Medicine owes to Physical Science is undoubtedly the discovery of the X-rays in 1895 by Wilhelm Röntgen, Professor of Physics at Würzburg.

As so often happens, this discovery was made possible by the earlier work of others, notably Hertz, Fleming and Crookes. By their experiments they had been able to explain many of the phenomena which occur when an electric spark crosses the gap between the two electrodes or terminal points of an electric circuit, enclosed within a vacuum tube, or one containing partially evacuated gases. The details are far too technical to discuss here, but, briefly, a reason was found for the fluorescence or glow which occurs on the glass of the tube, when the current is switched on and gives such a beautiful effect to the experiment ; the same reason, incidentally, explained why ordinary electric light bulbs with carbon filaments gradually became darker with use. In both instances the energy of the spark at the negative or *kathodal* electrode is able to displace the electrons of the atoms of which it is made, and some of these electrons are driven off at an incredible speed and bombard the walls of the tube. The impact produces the effect of a glow, and, with a carbon terminal or filament the gradual darkening of the glass from deposit of minute carbon particles. Now these electrons given off by the kathodal pole of a vacuum or gas-filled tube are known as *Kathodal* rays, and they differ in many respects from Light rays, in refraction, reflection, and other characteristics.

It was while Professor Röntgen was experimenting with

the Kathodal rays in a special bulb he had made—for among other gifts he was an expert glass-blower—that he discovered the X-ray almost by accident. Accident, luck, or chance maybe, but as Pasteur said, "Chance only favours those who are prepared."

It happened that he was conducting an experiment in a dark room with one of his bulbs covered up to exclude any issue of light. A short distance away there happened to be lying a glass plate coated with a substance—barium platinocyanide—which glows or fluoresces when exposed to light. When the current was switched on through the completely covered bulb, the coated plate became luminous, showing that it was excited by some agency which could pass through the dark covering of the bulb. Using the plate as a test, Röntgen at once tried many objects and materials to see if they obstructed or transmitted the influence emanating from the bulb, and found that some objects such as metals or bone, threw a well-defined shadow of their form on the glowing plate ; other materials in varying degrees allowed the influence to penetrate through them. When his wife's hand was placed in front of the plate, and the current was passed through the bulb, a perfect shadow of all the bones with a ring on one of the fingers appeared, while the soft parts completing the contour of the hand were only faintly delineated in outline. Photographic plates were also found to be sensitive to the emanation. Consequently, when developed, they gave negative pictures of the *shadows* of objects which, like metals and bone, were obstructive in character, and fainter or no effects at all with others, such as layers of wood or paper or cloth, through which the emanation could apparently pass. To make a long story short, he soon found out that this mysterious new form of energy, revealed by its chemical effects on photographic plates, or fluorescent films,

belonged to a new order of rays until then unrecognized, and he therefore christened them the " Unknown " or X-rays.[1]

On December 8th, 1895, he described his work in a pamphlet entitled " On a new kind of Ray ", and in January 1896 demonstrated the effects of the Rays at a meeting of the Physical Society of Würzburg.

The demonstration was received with profound astonishment. Here was a new discovery which seemed like a miracle and could evoke neither cavil nor criticism, only wonder ; for anyone who stood in front of the fluorescent screen could see a picture of his own skeleton—or the buttons which fastened his underclothes. In a few days the news had flashed round the world and was received at first with incredulity ; and with no little joy by the Press in search of " copy ". The wildest reports spread abroad as to the effects which might be expected ; some of them serious, others half jocular. The *Pall Mall Gazette*, referring to the discovery, said :

> . . . one consequence of it appears to be that you can see other people's bones with the naked eye, and also see through inches of solid wood. On the revolting indecency of this there is no need to dwell and it will call for legislative restrictions of the severest kind. Perhaps the best thing would be for all civilized nations to combine to burn all works on the röntgen rays, to execute all the discoverers, and to corner all the tungsten in the world and whelm it in the middle of the ocean. Let the fish contemplate each other's bones if they like, but not us.[2]

In New Jersey, U.S.A., on February 19th, 1896, a bill

[1] It must be clearly understood that the X-rays are not the same as the Kathodal rays, but are waves or vibrations in the ether set up by the violent impact of the Kathodal electrons on the walls of the bulb. In modern tubes or bulbs the electrons are focused on a Tungsten plate inside the tube ; and it is from this plate that the vibrations or X-rays emanate in concentrated form.

[2] Quoted in *Science of Radiology*, by Otto Glasner, p. 8. (Baillière, Tindall & Cox.)

was introduced into the House of Legislature prohibiting "The use of X-rays in opera glasses at the theatre", and later on in London an enterprising firm "made prey of ignorant women by advertising the sale of X-ray-proof underclothing".

The significance of the discovery was appreciated to the full, however, by all branches of the Medical profession. An immensely powerful weapon, with undreamed-of future possibilities was at once placed in their hands. No longer would they have to rely on their unaided senses in dealing with disease or accidents of the bones or teeth, in locating foreign bodies such as bullets, or the detection of stony deposits in internal organs. Though not an actual picture, here at any rate was the next best thing—a faithful shadow which would provide a permanent record of all such objects.

Moreover, as these rays were able to pass through tissues other than the bones, why might they not do more than cast shadows? What might be their effect on cell structure and cell growth of the normal body; or on those abnormal and vagrant cells from which are born cancers and other tumours? For purposes of *diagnosis* the discovery appeared to be the greatest gift ever given to Medicine. No less did the imagination conjure up visions of the uses to which it might be applied in the *treatment* of intractable diseases.

Not only have these expectations been more than fulfilled, but they have been surpassed by the developments which followed. A new branch of Science, Radiology, has arisen, of which Röntgenology—an uncouth term—in its application to Medicine forms a subdivision. The amount of literature that has accumulated, the improvements in the apparatus, and the refinements of technique are bewildering. A doctor who specializes in this work must also be a highly skilled Electrician—a master of

Physics as well as Physic. A Röntgen ray and Electrical Department with a highly trained staff is nowadays as great a necessity to a modern hospital as an operating theatre, or a kitchen, and the heavy expenses of equipment (which quickly gets out of date) and general upkeep have greatly added to the already heavy burdens of hospital finance.

No attempt can be made here to convey any idea of the complicated tubes, mechanical appliances, and general technique required for the application of X-rays. Special knowledge is required to understand even the simplest description of their detail. But a brief sketch of the uses made of these wonderful rays will not be out of place.

First comes Diagnosis. A Röntgen ray skiagraph or shadow photograph (Greek *skia*, a shadow) is now considered essential in all accidents or diseases of the bones. It frequently discloses a fracture which could not otherwise be detected, and if one has happened, it shows the position of the fragments before and after the "setting", and later on the formation of new bone in the process of repair (Fig. 30*a*). Consequently, from beginning to end, we have a sure guide which can be relied on. The actual setting of a fracture is often performed with the aid of the fluorescent screen, since it shows at once if the bones have been brought into proper position; needless to say this is a great help to the manipulations of the surgeon.

Now bones vary in density in their different parts, from the hard outer portion, through the loosely woven intermediate layers, down to the hollow interior (in a long bone) which contains the marrow. The denser the part the deeper the shadow, with the result that we can see mapped out the beautiful details of its architecture. If disease is present, it is possible to see the thickening and irregularity of outline caused by an early new growth (tumour); or the thinning and absorption by a chronic

inflammation (tuberculous); or the formation of an abscess.

It must be clearly understood that the degree of obstruction of different substances to the passage of X-rays depends on their character and density; metals and bone give well-defined shadows on a skiagraph, but with modern X-ray tubes, dense bodies like the liver and heart will also show fairly well-marked outlines, though fainter

FIG. 30*a*. FRACTURE OF LEG—TIBIA AND FIBULA

(By courtesy of Dr Sankey, Oxford)

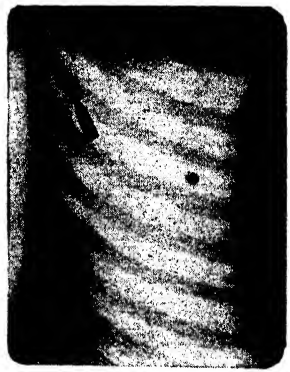


FIG. 30*b*. BULLET IN CHEST

(By courtesy of K.E.F.)

in definition than bony structure. The lungs full of air are almost transparent to the rays, but thickenings caused by inflammations or deposits, such as abscesses, tubercle, or growths, will give shadows which are absent in a healthy organ.

X-ray work has by no means proved the easy job it was first thought to be. The pitfalls are many and various. In the first place, the pictures are only shadow presentments, and the outline of a shadow and its relation to surrounding objects alter with the angle of the light

producing it. Again, other objects in the line of light, however near or far apart, are seen in the same plane as the object in question ; for example, a row of waistcoat buttons, if the garment was in place, would appear as discs on the shadow of the spinal column. Instances could be multiplied indefinitely, but it is sufficient to say that *interpretation* is the highest and most difficult branch of X-ray technique. A very great advance was made when two pictures of the same object were taken from different angles, and then combined in a stereoscope. In this way the details could be seen in their proper perspective, and in cavities, such as the interior of the skull, the depressions and projections in the bone can be seen in their correct relative positions.

Foreign Bodies

It is hardly necessary to dwell on the use of X-rays in detecting the presence and position of foreign bodies, such as bullets (Fig. 30*b*), shell fragments, metallic objects that have been swallowed (Fig. 30*c*), and stones that have formed in the bladder or kidneys (Fig. 30*d*). The remarkable successes of surgery in the Great War could not have been attained without the well-equipped X-ray departments in every hospital, and in the travelling units which visited the moving Casualty Clearing Stations behind the lines. All sorts of ingenious devices in X-ray work were invented during the war for locating the exact position of a buried fragment of shell, or a bullet. Among others was a telephone probe which emitted clicks when it touched a metallic surface.

There must be a long list of curious objects that have been swallowed by accident and their whereabouts disclosed by X-rays. On Fig. 30*c* will be seen a skiagraph of a toy bicycle stuck in a child's gullet. Some of these

articles with projections may cause damage and have to be removed ; others from their rounded shape are better left alone. It is quite exciting to watch in a series of pictures the safe passage of a halfpenny, or button, or iron nut, through the tortuous coils of the bowels, until, after a few days, it again reaches daylight, and is carried off by a delighted mother to be treasured with the family heirlooms.

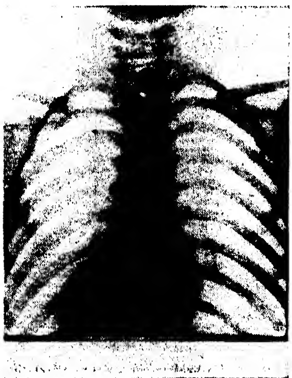


FIG. 30*c*. TOY BICYCLE IN GULLET
(By courtesy of K.E.F.)

FIG. 30*d*. STONE IN KIDNEY
(By courtesy of Dr Sankey, Oxford)

But the radiologists are not content with such simple practices as these. Certain chemical substances, which give a shadow with X-rays, are employed to coat the walls of internal organs, such as the stomach, intestines, kidneys, gall bladder, and even the sensitive bronchial tubes. An X-ray picture will then show an outline of the organ, and any abnormalities in its position or shape, or obstruction in the passage of its contents. The commonest method is the " Bismuth, or Barium Meal ". A small quantity of the powder suspended in water is swallowed, and at

various intervals pictures are afterwards taken. The passage of the meal can be watched, and the shadow gives a faithful outline of the section of the alimentary tract where it is lodged, and affords valuable information as regards obstructions, or ulcers, or growths (Fig. 30*e*). Other chemicals injected *into the blood*, or taken by mouth, will enable a picture to be taken of the interior of the kidney, or gall bladder. Perhaps the most wonderful is a compound of iodine and poppy oil, which can be squirted down the windpipe, without giving rise to any pain or coughing, and will then give a picture of the bronchial tubes, very much resembling the trunk, branches, and twigs of a tree (Fig. 31). It is absolutely necessary that the radiologist should know the appearances of the organs as displayed in health before he can be certain about the appearance in disease. With X-rays the early stages of disease can often be detected long before it would be possible to recognize them by any other means, as in tubercle of the lungs.

FIG. 30*e*. BISMUTH MEAL IN STOMACH
(By courtesy of Dr Sankey, Oxford)

In recent years further important progress has been made by the use of the Cinematograph, or the Microscope, in conjunction with X-rays, to demonstrate the movements of living organs, and even the changes taking place in living cells. By special slow motion technique it is now possible to watch a human heart beating and study its rhythm ; or see a fluid swallowed, enter the stomach, and be ejected into the intestine ; and, most marvellous of all, in the slow motion Canti film we can

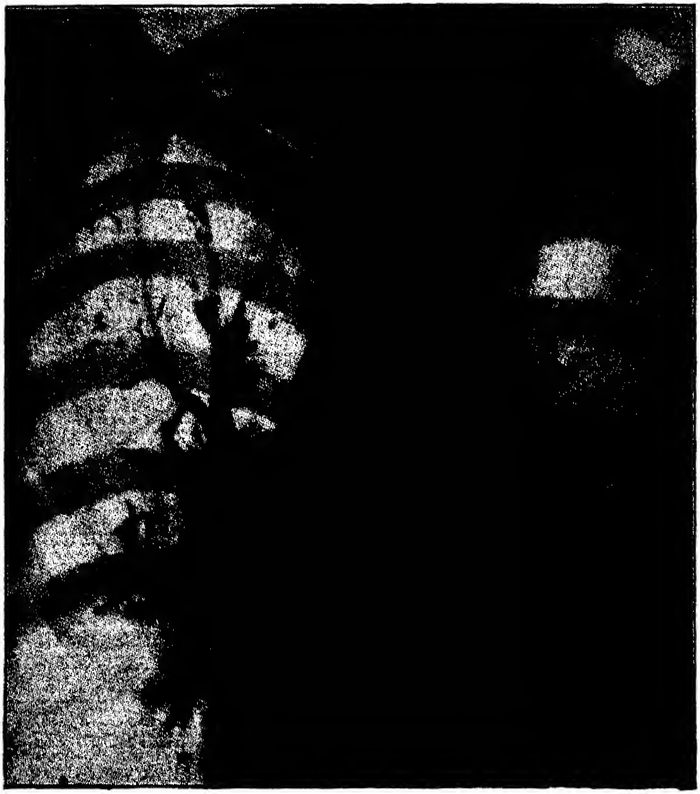


Fig. 31. Skiagraph of Chest after Injection of Lipiodol into Windpipe

Note: 1. Dark outline of heart (below)
2. The lungs almost transparent
3. The branching of the bronchial tubes
4. The windpipe and spine forming a combined shadow
5. The outlines of the ribs, and collar bones

From *The Uses of Lipiodol* by J. A. Sicard and J. Forestier. (Reproduced by the courtesy of the Oxford University Press.)

see the attacks of germs on the body cells, the details of the fight, the movements of the blood corpuscles, and the advancing invasion of a cancer, as it infiltrates the tissues.

X-rays in Treatment

It was not long after the discovery of the "photographic" effects of X-rays, that attention was turned to their use in treatment. That they exercised a powerful action on the skin was soon evident by disasters that overtook many of the early investigators. Hands and arms constantly exposed to the rays developed all the appearances of a severe burn, and the functions of internal organs became impaired. The exact effect of the rays on the living material of a cell is still a matter of conjecture, and probably has to do with some alteration of its molecular or atomic arrangement, for the margin between a healthy stimulus to its activity, and a destructive effect on its life or growth is not a wide one. Patient research has elicited one hopeful fact. In some diseases of the skin, and in cancers and tumours with cells which differ from the natural body cells, the X-rays, and also Radium, exercise their destructive effect more readily on the disease cells than on the neighbouring healthy ones. The curative power of the rays necessarily depends on the depth of their penetration, and the greatest successes have been secured in many intractable and comparatively superficial skin diseases of parasitic origin, such as ringworm, and in semi-malignant growths or ulcerations. The most delicate adjustments and appliances are necessary to safeguard against over exposure or burns, and to limit the effect to the affected area. So successful have been the rays in superficial diseases that in recent years great progress has been made in their application to diseases of the deeper organs and tissues, particularly malignant growths,

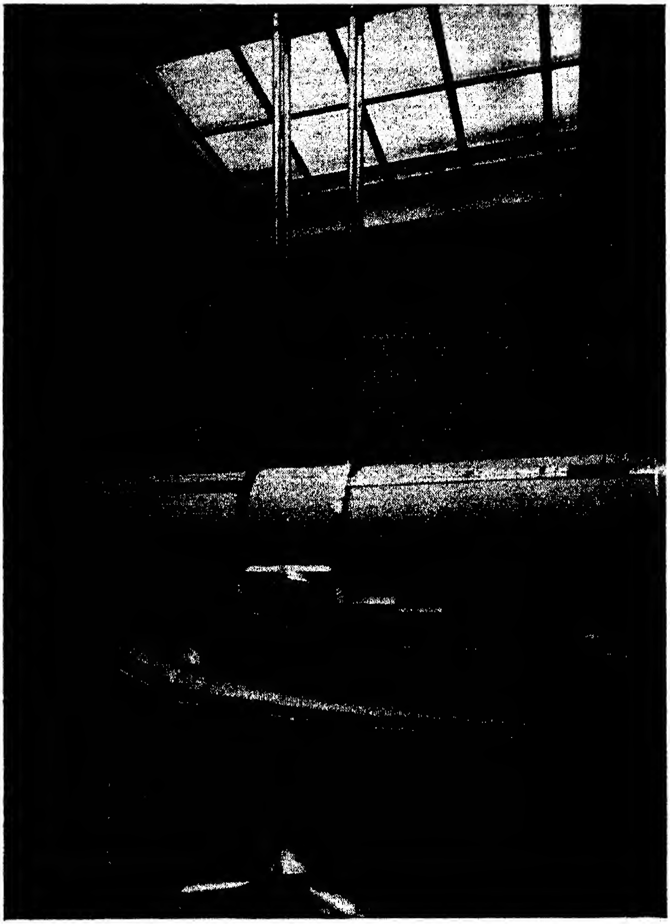


FIG. 32. TREATMENT ROOM AND X-RAY TUBE IN THE MOZELLE SASSOON HIGH VOLTAGE DEPARTMENT FOR CANCER AT ST BARTHOLOMEW'S HOSPITAL

(By courtesy of St Bartholomew's Hospital and the Metropolitan Vickers Electrical Co., Ltd.)

or their recurrence in internal organs of the body. Immensely powerful currents of electricity are needed to produce the high frequency rays required for this " deep " treatment ; and the precautions and adjustments in the technique are correspondingly elaborate. Until lately a generating voltage of about 200,000 was considered a maximum, but radiologists ask for more and more, and the newest wonder (1937) is the installation at St Bartholomew's Hospital (through the generosity of Mrs Meyer Sassoon), of an apparatus which requires a building all to itself, and can be operated at a voltage efficiency of 250,000 to 1,000,000 volts ; the X-ray tube alone in this stupendous apparatus is nearly 10 yards long and 4 feet in diameter, and yet little more than thirty years ago, the glass bulbs in use were about the size of a coconut !

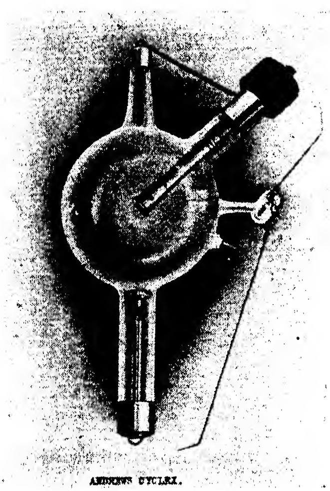


Fig. 33. An Early X-ray Bulb
(By courtesy of K.E.F.)

Probably a vague feeling of uneasiness takes possession of a person, more especially if he be a patient, who for the first time enters one of these chambers where such powerful forces for good or evil are bottled up. He treads gingerly amidst the mysterious appliances which surround the elaborate couch on which he may have to lie, or enters doubtfully a kind of sentry box where he will be screened and perhaps get a glimpse of his own bones. It all rather suggests an electrocution, and with nothing but faith to offset his ignorance, he may well be pardoned for a

silent prayer that the doctor in attendance knows his job.

He may rest assured. Only a very highly trained man and competent assistants can be put in charge of forces such as X-rays, and in the last forty years knowledge gained by bitter experience has taught us how these forces may be controlled, and dangers safeguarded. The experience has been gained at the cost of life and limb to many of the pioneers. It was not realized at first that *constant* exposure to X-rays causes a deep-seated inflammation of the skin, which later on ulcerates, refuses to heal, and may become malignant. Early in the century Dr Hall Edwardes, of Birmingham, lost both his hands, Dr Blacker of St Thomas's Hospital, his life; and at one time or another since, thirty doctors and nurses have died besides others who have been injured.[1]

The danger lies in constant exposure, or too long an exposure at one time. This can readily be guarded against with patients, but it is not so easy with the doctors and nurses who are more or less constantly exposed. In addition to the direct rays from the lamp there are *secondary* rays set up by the action of the direct rays on objects which they strike—even the body of the patient. Lead is the best protection against the rays, and for many years past operators have been accustomed to work either behind screens or wear gloves and aprons lined with this metal. With high voltages for deep treatment, such as the new installation at St Bartholomew's, the tube where the rays originate is heavily insulated except opposite the window from which they emerge, and the treatment takes place in a completely lead lined room which is occupied at the time by the patient alone. The observer in control watches through a lead glass window, and controls all his apparatus from a switchboard. Communication with

[1] Masters, *Conquest of Disease*, pp. 275–6.

patient is made by microphone, and the opening of the door can be made to shut off the current, or revolve the tube window opposite to a block of lead which absorbs the rays. Blocks of barium concrete can be used instead of lead for outside walls.[1]

And the cost! Bear in mind that a "Deep X-ray" department is only one of the departments of a general X-ray department, which again is generally a part of the Special Electrical department of a hospital, and all of these are very costly affairs to install and maintain. An up-to-date installation with its building may well run to £20,000 or more, and an X-ray tube alone costs from £100 to £120. After a very few years, moreover, new discoveries and improvements may render a large number of the appliances obsolete. No one who is acquainted with the cures that have been effected in the last few years in cancer and other malignant diseases, with the relief of pain and suffering in incurable cases, and with the prospect of still better results in the future, will deny that all this expense is justified. It seems a drop in the ocean compared with the cost of a new battleship, but it has to be met by the voluntary subscriptions and benefactions on which hospitals depend for their finances; and another form of magnetic ray which would exert its effects on well-lined pockets is badly needed.

[1] For the above information I am indebted to the kindness of Dr Ralph Phillips, Cancer Department, St Bart's Hospital.

Chapter XVIII

RADIUM [1]

The discovery of X-rays by Röntgen in 1895 and of Radium by Madame Curie in 1898 were a fitting conclusion to a century in which nearly every decade saw the birth of some new wonder of Science. Of all these, Radium is perhaps the most distinctive, for its qualities have revolutionized all our ideas of the physical universe, and it has been the means of displacing the atom from its proud position as the final unit of which matter was once believed to be composed. Only a brief account can be given here of those of its physical properties which have been turned to account in Medicine; but the discovery itself, and the devices which have subjected this fiery and powerful element to our service add another touch of romance to the story of Medical progress.

An impetus was given to the study of fluorescence by the part this phenomenon had taken in the discovery of X-rays, and in 1896, a French physicist, Becquerel, experimenting with a rare element, uranium, which possesses this property, discovered that it would also act *in the dark* on a photographic plate and consequently must be able to emit some ray with chemical powers. Here the story of Madame Curie begins.

Marie Sklodowska was born at Warsaw in Poland in 1867. She came of a scientific family and early in the nineties was studying physics at the Sorbonne in Paris. With great natural gifts for research, she, like many others, was inspired by Röntgen's triumph and the later

[1] In the following pages much information has been gained from a paper on "Radium and its Surgical Applications", by Mr H. Souttar, F.R.C.S., *British Medical Journal*, 1929, p. 538.

discovery of Becquerel, and began the laborious task of testing all the known metals, as well as other elements, for the properties already found to exist in uranium. At this same time there was also working in the laboratories at another subject, a brilliant young Frenchman, Pierre Curie. Even in the unromantic atmosphere of a physical laboratory there may occur from time to time attractions not confined to electrons and protons. This was the case with Marie Sklodowska and Pierre Curie. They married, and their mutual interest in research made their union a very ideal one; perhaps without it the great discovery would not have been made. For Monsieur Curie gave up his own research to join his wife in a quest which had given indications that she was on the verge of a great discovery.

Uranium is a constituent of a metalliferous ore called pitchblende, which is found in certain parts of the world (the Belgian Congo, Australia, United States), and among others at Joachimsthal in Bohemia. Madame Curie noticed that the crude ore gave indications of a greater ray activity than could be accounted for by the amount of uranium it contained. She assumed that there must exist in the pitchblende another unknown substance of greater activity than uranium.

The search for this unknown source of energy was at once undertaken by these two young enthusiasts, though the difficulties appeared to be almost insurmountable. Not the least was the great bulk of crude ore which had to be tested and reduced to obtain the minutest quantity of active substances. Their little laboratory was no place for the cartloads of stuff, every ounce of which had to be tested, and eventually they had to migrate to the mines in Bohemia, where they built themselves a dwelling hut and working room, and started on their voyage of discovery.

In the event, the explorers were able to obtain from the ore dumps, a minute quantity of an entirely new element (about 1 gramme (15·4 grains) to every 25,000 pounds of ore = 11 tons). Owing to its ray activity it was called Radium, and another active *element*, which was afterwards found to be a later phase in the transformations which Radium undergoes, was called Polonium, in recognition of the native country of the discoverer. They had indeed called up a genie which has upset all the previous theories of the construction of the Universe, and possesses magical powers for good and evil; a genie with greater powers, and capable of more wonderful transformations, than any we read of in the *Arabian Nights*. Securely chained it can be made to serve, but let loose it can play the devil. A few words must be afforded in explanation.

Under the "Atomic theory" all the discovered elements were thought to be fixed and unchangeable in themselves, though capable of chemical combinations. It is now known that some elements undergo more or less gradual transformation into other elements, each of which is the product of the last. The uranium family constitutes such a series. The atoms of these radioactive elements are of extremely complicated construction, with numerous electrons and protons held together by more or less strong attraction. Some of the more loosely held are constantly flying off into space, and those left behind form themselves into new atoms with a different arrangement of electrons and protons to that of the parent atom, i.e. they form themselves into a new element. The new element likewise loses some of its electrons and protons, and again another element is formed, and so on down the years until the original element has slowly disintegrated away and entirely disappeared. The character of each generation, whether solid, liquid, or gas,

may be different from that of its preceding one, and the duration in time of one phase may be thousands of years, and of another only a few minutes.

The table below shows the transformation of Uranium, the heaviest known element, through the various forms of Radium until its final stabilization in Lead.

As regards the radioactivity of these elements there are three different kinds of rays which they emit: (1) alpha (α) rays, the positively charged protons or particles which emanate from the nucleus or centre of an atom. (2) the beta (β) rays, the negatively charged electrons which

Element.	Atomic Weight.	Radiation.	Half-value Period.[1]	
Uranium 1 .	238	α $\beta\beta$ (beta)	5,000,000,000	years
Uranium 2 .	234	α (alpha)	2,000,000	,,
Ionium . .	230	α	140,000	,,
Radium . .	226	α (β)	1,750	,,
Radon . .	222	α	3·85	days
Radium A .	218	α	3	minutes
Radium B .	214	$\beta\gamma$ (gamma)	26·7	,,
Radium C .	214	$\alpha\beta\gamma$	19·5	,,
Radium D .	210	β	17	years
Radium E .	210	β	5	days
Polonium .	210	β	136	,,
Lead . .	206			

[1] i.e. period during which each element diminishes by one half of its mass.

revolve round the nucleus. (3) gamma (γ) rays, neither protons nor electrons, but waves in the ether set up by the commotion caused by the discharge of electrons from the atom, just as sound waves are produced by the discharge of a gun. To indicate the medical effects of these various rays and their powers of penetration, the

alpha rays may be compared with the wads of a cartridge, the beta rays with the shot, and the gamma rays with the sound waves, when a cartridge is fired. The alpha and beta rays possess great energy, and destructive powers on the bodily tissues, but they are unable to penetrate farther than about half an inch; and they can be stopped altogether by a thin plate of aluminium or silver. The gamma, or hard rays, of very short wave length and high frequency of vibration, are the ones chiefly used in Medicine. They possess great powers of penetration, and can pass through several inches of lead, and their strength is reduced by only 50 per cent. after passing through 4 inches of body tissues. Platinum is the metal which stops them most readily.

An act of malevolence by the demon which the Curies had called into being, first drew attention to the dangers it might cause when uncontrolled, and conversely to its uses when regulated. Becquerel, after carrying a few grains of radium in his waistcoat pocket, was severely burnt, and numerous experiments were then made to test its effects on living cells. Pierre Curie deliberately exposed his arm to radium, and received a severe burn which took months to heal.

As with X-rays, radium exhibits a selective action on healthy and diseased cells, and astonishing results were obtained in the treatment of superficial disorders and growths. Warts, blemishes, and rodent ulcers melted away under its influence, and were replaced by healthy skin. In recent years ingenious improvements in apparatus and technique have made its application possible to deeper growths of cancers and other tumours beyond the reach of Surgery; and there are many surgeons who now employ radium treatment in conjunction with, or in preference to, the knife.

With such powers, and yet obtainable in only very

small quantities, radium has become by far the most valuable of all substances. The original price of a gramme (15·4 grains) was about £12,000, and though it slowly disappears into other transformations this does not much diminish its value since it takes 1,750 years to lose half its weight. A glance at the table will show that Radon follows Radium in the transformation series, and this substance happens to be a heavy gas which is always being emitted, and quickly undergoes further changes in days or minutes into Radium A, B, C. These "emanations" can be collected as gases, and sealed up in small tubes, and while they last are as efficacious as radium itself. With a small stock of radium for capital, which remains practically unchanged, the emanations can be used freely as income, with the comfortable assurance that whenever needed further dividends can be obtained without depreciation in value of the stock.

Various types of "containers" are used to hold the radium (or its salt, radium sulphate), for superficial application. They are made of platinum or silver in order to shut off the harmful alpha and beta rays. For deeper work, from 1 to 5 milligrams of the substances are inserted into hollow platinum needles with a diameter of 1–3 millimetres, or into "seeds", viz. small silver capsules which contain a tiny bubble of the radon gas. These needles or seeds are inserted into the growth which it is desired to destroy, and allowed to remain for some hours or even days, and they cause very little discomfort. This description is introduced merely to give some idea of the marvellous delicacy and accurate technique required to deal with a substance that can exert such extraordinary powers in so small a compass, and yet must always be kept under rigorous control.

Of the efficacy of radium in the cure of several forms of cancer there can be no doubt. Most of the disappoint-

ments come from cases where treatment has not begun sufficiently early, while the growth is still localized ; or when the growth is in an inaccessible region of the body. In the latter the deep X-ray treatment still affords hope. The insistent cry of Surgeons and Radiologists is " Come early, or when in doubt."

What of the after history of this remarkable couple, the young Curies, who had brought all this to pass? And of Becquerel? Among other honours Madame Curie was awarded the Davy medal of the Royal Society, and Becquerel and Pierre Curie each received the Nobel prize for Physics ; the Curie's name has also been perpetuated in the title of the unit of radioactivity—a " Curie ", or its one-thousandth part—a millicurie. And then followed a tragedy for them and the world. In 1906 Pierre Curie was killed in a street accident in Paris, and the ideal partnership was ended. With great bravery his wife continued the work so brilliantly begun, and she became Professor of Physics at the Sorbonne, and Head of the Curie Institute which was established for research in Radio-physics. She died in 1934 probably from a disorder " due to the constant and relentless action of the rays which she had discovered ".[1]

Apart from the more dramatic discoveries of the effects of ultra-violet, radium, and X-rays in Medicine, great advances have been made in other forms of electrical treatment, and in the instruments and appliances by which they are conveyed. For example, high frequency currents are now used in what is known as *Diathermy* Treatment, by which heat can be conveyed to the joints, muscles, and internal organs, or used with special cautery knives to perform a bloodless operation, or to destroy a growth, and for many other purposes.

In fact there is now hardly any region of the body

[1] Wyndham Lloyd, op. cit., p. 208.

which the radiologist does not claim as a province into which he has a right to enter, and where he can justify his intrusion by successes which have not always rewarded the efforts of physician or surgeon. And the end is not yet. Surgery is a fine art, and has had a long and successful reign, but when all is said it is a crude way of curing disease. Even to-day many a surgeon finds that his skilled touch can be equally well adapted in handling a radium needle as a scalpel, and future developments in physics and biochemistry may still further render unnecessary the use of an instrument which tradition has established as the symbol of his art.

Physical Science, no less than Biology, and Chemistry may well be proud of the contributions it has given to Medicine in the last fifty years.

Chapter XIX

NURSING

Any survey of Medical progress must include some reference to Nursing, one of the most important features in the treatment of disease and the relief of suffering.

Only brief allusion can be made to the evolution of Nursing from its dawn in the early years of the Christian era to the beginning of the modern period in the middle of the nineteenth century.

During nearly the whole of these nineteen hundred years, nursing was almost entirely connected with and under the control of religious foundations. Indeed the care of the young, the sick, and the aged, has always been one of the most distinctive features of the practice of Christianity.

In the very early years there were the Deaconesses, mentioned by St. Paul, who visited and nursed the sick in their own homes. These were followed in the sixth century by the Nuns of various religious orders—Benedictine, Cistercian, Augustinian, who in addition to home visits, "staffed" the infirmaries, hospices, or other institutions mostly under the control of abbeys or various religious foundations.

The Crusades gave rise to the great Military Orders concerned with the care of the sick and wounded—the Templar and Teutonic Knights, and the Knights Hospitallers of St John of Jerusalem. After the Crusades the latter Order was placed in possession of the island of Malta, and after undergoing at a later date many vicissitudes, continue its activities at the present time and is associated with the well-known St John Ambulance Brigade.

Secular orders for women were established abroad as early as the twelfth century. One of the most important was the Order of Béguines in Belgium, which still exists and did admirable work in the Great War. Although no monastic vows are taken, a conventual pattern is adopted, and the Béguinages consist of separate houses, surrounding a chapel, guest house and hospital. In the seventeenth century came the great work of St Vincent de Paul who instituted at Paris the Sisters of Charity, for work in patients' homes, as well as at the hospitals. At first a lay sisterhood, it afterwards came under ecclesiastical influences, and its activities were no longer limited to nursing and the training of nurses as intended by the Founder.

In England there appears to have been no secular nursing orders, and down to the dissolution of the monasteries in the sixteenth century, nursing in hospitals or other institutions was performed by nuns. They also visited the sick poor in their homes, and doubtless there were many Lady Bountifuls in the great feudal Castles, who devoted themselves to nursing, as well as to dispensing charities to the serfs, villeins, or other feudatories on their estates.

The restrictions imposed by taking the veil, the priority accorded to devotional exercises, and the lack of organized training, were serious obstacles in the path of attainment to nursing efficiency. But the religious impress of those early centuries created a priceless tradition, inherited by every nurse who takes up her work from the same motives of self-sacrifice and charity which inspired her predecessors; strikingly exemplified in modern times by Florence Nightingale.

After the dissolution of the monasteries and nunneries, nursing, on account of the low estimation in which it came to be held, fell on evil times. It gradually devolved

upon an inferior class of women of no education or training, who turned to midwifery or nursing for want of something better to do.

Here for instance is a charge given to a Sister on entering upon her hospital duties in the sixteenth century; a charge hardly necessary it may be hoped in the case of Nuns, but not inappropriate to the class of women who took over their duties:

> Ye shall not haunt or resort to any manner of persons out of this House, except ye be licensed by the Matron, neither shall ye suffer any light person to haunt or use unto you, neither any dishonest person, either man or woman, and in so much as in you shall lie ye shall avoid and shun the conversation and company of all men. And above all things see that you avoid, abhor, and detest scolding and drunkenness as most pestilent and filthy vices.[1]

Later on we need hardly believe that the lurid pictures drawn by Charles Dickens of Sarah Gamp, and Betsy Prig, were typical of the ordinary nurse. Although ignorance, dirtiness, drunkenness, and peculation were undoubtedly not uncommon characteristics of their profession, there must have been among them many of those kind, trustworthy, capable, if untrained women who seem born for the purpose of caring for the sick and helpless; women who never get tired, who want no "times off", and who will turn their hands to do other jobs, make themselves useful in the home, and yet keep their status of Nurse. A real friend in need, this type of untrained nurse is becoming nowadays a rarity, and her place is not always filled by the competent, certificated Nurse who, quite correctly, keeps within the strict limits of her professional duties and regulations.

In the first half of the nineteenth century, in the larger Hospitals, the Sisters and Nurses were chosen

[1] Sir D'Arcy Power, *History of St Bartholomew's Hospital*, p. 40.

from among these valuable untrained women. They picked up their own training by experience, without lectures or examinations, and, though often uneducated, they became most excellent nurses, with an instinctive knowledge of the way a case was going, the little signs which means so much, and the right thing to do. Their only object in life was the care of their patients, and their devotion to the Ward, and the Physician or Surgeon in charge. Outside the hospital, and in unfamiliar surroundings, they were as lost souls, and many of them looked forward with dismay to the obligatory annual short holiday.

As Science entered more and more into the practice of Medicine, the importance of a properly trained and better educated class of nurse became evident, and a new era in Nursing began in 1854, owing to the genius and inspiring example of Miss Florence Nightingale.

No attempt can be made here to retell the tale of this great Englishwoman. To appreciate to the full her character, her genius, and her incredible labours no detail should be omitted. Fortunately we possess in her biography by Sir E. Cook, and in a brilliant essay in *Eminent Victorians*, by Lytton Strachey, narratives which can satisfy our imagination, and infuse with life the marble figure with its calm, thoughtful features, which stands to her memory in Waterloo Place. The lamp in her hand was probably a concession to popular fancy. Although she was known as the "Lady with the Lamp" and as a "Ministering Angel" to the wounded, her work of some twenty months in the Crimean War was in reality but a brief incident in her career. It was an incident nevertheless that gained for her a position from which, during a long life, she was able to overthrow numberless abuses, and introduce reforms, which have revolutionized nursing, the construction of hospitals, and

the organization of all that pertains to the health of the Army in Peace and War.

How was it possible that changes of such magnitude in the organization of a vast machine like the Medical Department of the War Office, or in the attitude of the authorities who managed it, could have been effected by a young woman hardly out of her twenties? Against her was the dead weight of administrative incapacity and incompetence in the hands of highly placed officials and officers, entangled in a traditional routine of red tape and formulas, complacent in any disaster, so long as papers were in order and docketed in the right pigeon holes. Against her, too, was the popular opinion that nursing was a somewhat disreputable calling, with a low standard of ideals and morality, and not in any way a suitable occupation for a young lady of gentle birth. The making of such a revolution was only possible to one possessed with a dominant purpose, an indomitable will, and an untiring persistence in attaining an object. To these qualities were added intellectual capacity, a genius for organization, and above all, powers of vision and a knowledge of detail superior to those possessed by any with whom she crossed swords. She was born with a passion for the care of the sick and needy; a passion which in after life possessed her like a Demon.[1]

Her early womanhood was one long struggle to escape from the social trammels in which she was enmeshed, and it was an easier task to subjugate the Officials at Whitehall, or the Colonels at Scutari, than to overcome the solicitudes and wishes of her anxious parents who, comparing themselves to ducks, declared they had hatched a "wild swan". What could be made of a daughter who in foreign travels found her chief interest in visiting hospitals and charitable institutions, studying

[1] Lytton Strachey, *Eminent Victorians*, p. 115.

their organization, and compiling statistics, and who grudged the time spent in doing the round of the picture galleries, or taking part in the social distractions of gay capitals?

After years of waiting she at last obtained her parents' consent to go to Kaiserswerth in Germany, where there was a large Protestant Institution for the training of nurses, associated with a Hospital and Penitentiary. It was there that she acquired a practical knowledge of nursing and hospital organization, and, after a short time spent in Paris with the "Sisters of Charity", she returned to London in 1853 to take up the post of Superintendent of a Home for Invalid Gentlewomen. In 1854 came the opportunity which found her prepared, and afforded scope for her genius. The reports in *The Times* had laid bare the terrible conditions of the sick and wounded in the Crimea, and the breakdown of the medical arrangements, and at once aroused popular indignation and alarm. A large fund was collected for sending out medical and nursing supplies. Sidney Herbert, then Secretary at War, offered her the post of Nursing Superintendent, and after collecting a body of thirty-eight nurses, she left for Scutari on November 4th, 1854. On board, one of the little company said to her, "Oh, Miss Nightingale, when we land don't let there be any red-tape delays; let us get straight to nursing the poor fellows." "The strongest will be wanted at the wash-tub," was the disillusioning reply.[1]

The horrors of the Hospital, the confusion and mismanagement of the organization, and the revolution that was effected by Miss Nightingale are part of our National History, and have been told by abler pens.[2] It is sufficient to say that within six months a mortality of 42 per

[1] Eleanor Hall, *Florence Nightingale*, p. 30.
[2] Sir E. Cook, *Life of Florence Nightingale*. (Macmillan, 1913.)

100, was reduced to 2·2 per 100; the men were properly clothed and fed; and every defect in the hygienic arrangements had been corrected. And all this was done by a young woman of thirty-four, who by sheer force of personality, knowledge, and clear vision, gained her way and brought to her side those who at first bitterly resented her presence and scoffed at her efforts. It must be remembered, however, that in Sidney Herbert at the War Office she had a staunch supporter, and behind her was the popular clamour for reform, and large sums of money by which she was able to supply urgent needs. Although her health broke down, she refused to leave the war area until the hospitals were closed down in July 1856, four months after peace had been declared.

She returned as a National Heroine, but avoided publicity of every kind, including the offer of her passage home on a warship. Nevertheless she was summoned to Balmoral, and received a letter of thanks from the Secretary of State, "on behalf of himself and his colleagues, and to express the unanimous feeling of the people of this country".[1]

A Nightingale Fund was formed for the purpose of founding a Training Institute for Nurses, and this, the first of its kind in England, was established at St Thomas's Hospital in 1860.

Her life's work began in reality after the war. Her experiences had left an indelible impression on her mind, and though for the next fifty years she had to lead the life of an invalid, she was possessed with a burning zeal for the reform of numerous defects and abuses which stood in the path of progress in Health, Hygiene, and Nursing.

She collected around her a bevy of workers (her Cabinet), chief of whom was Sir Sidney Herbert, now

[1] E. F. Hall, op. cit., p. 35.

Minister *for* War, and through his influence a Commission was appointed to enquire into Army Medical Administration. As a result a complete reorganization of this Department took place. She became a leading authority on all that pertained to hospital construction and hygiene, a mistress of detail and statistics ; pamphlets on a variety of kindred subjects issued from her pen, and her position as a referee or adviser entailed a vast correspondence at home and abroad. So great was her reputation that her advice was sought in the reorganization of the Hospitals and Sanitary Departments of the Army in India ; by America in the Civil War ; and by both the combatants in the Franco-German War of 1870. France conferred on her the bronze cross of the Societé de Secours aux Blessés, and Germany the Cross of Merit. Her writings were chiefly in the form of Reports, Suggestions and Notes. The most widely known is *Notes on Nursing*, which immediately after it was published had an enormous sale and was translated into several languages. Not only were these notes of the highest practical value, but they set up standards of morals, conduct, and ideals which constitute a model for every woman who takes up nursing as a profession. As someone has well said of these Notes : "They have taught Ladies how to be Nurses, and Nurses how to be Ladies." With her own little Cabinet of fellow workers, collected in her sickroom, she herself set a standard which was indeed difficult to follow : she craved for work, was exacting in her demands, and was ever insisting on greater efforts being made to accomplish a particular object.

Her relations with Sidney Herbert are of absorbing interest. He was a man of noble character and charming personality. A friend of Miss Nightingale's from childhood, he was inspired at the War Office with her zeal for reform, and became a ready coadjutor in her schemes.

She, with her driving force and knowledge of detail, was the influence behind the scenes, while he was the political power to carry out her projects. The brunt of the opposition fell chiefly upon him, but still she spurred him on. The strain of the War, and the yet greater strain in carrying through Parliament the necessary reforms at last broke him. Illness to Miss Nightingale, however, was no excuse for relaxation, and her attitude when he resigned office almost suggested reproach and a sense of failure. He died, worn out, at Wilton, in August 1861, and his last words were those of regret: "Poor Florence! Poor Florence! our joint work unfinished."[1]

Long before she became old, Miss Nightingale was fortunate to see the reforms she had initiated carried out, and almost to the last her tenets and experience were important influences in the nursing world.

In 1887–93 she took a leading part in what has been called "The Battle of the Nurses"—a contention which arose between two conflicting schools of thought. There were many who thought that nursing should become a definite Profession after a course of training and examination, and were in favour of State Registration. Miss Nightingale saw in this scheme a departure from her ideal that the essence of nursing was a "calling", Vocational in character as opposed to Professional. Highly trained as she wished all nurses to become, she yet attached greater importance to the moral, religious (not sectarian), and altruistic qualities which could never be elicited by examinations or a Register. However, a new generation had risen with fresh ideas, and in 1887 the British Nurses' Association was founded, with the object of obtaining a Royal Charter, and eventually a State Register (The Charter was granted in 1893). In the same year (1887) the Jubilee Institute of District Nurses

[1] Sir E. Cook, *Life of Florence Nightingale*, p. 406. (Macmillan, 1913.)

was founded to commemorate the Jubilee of Queen Victoria, and another Royal association with nursing was established in 1902 with the formation of Queen Alexandra's Imperial, Naval and Military Services. (The red uniform cape worn by the Sisters is modelled on that originally introduced by Florence Nightingale for the nurses whom she took with her to Scutari.)

In 1899 an International Council of Nurses was founded, with branches in almost every country in the world, and its membership at the present time is 150,000. The College of Nursing was established in 1916, membership of it being limited to nurses who have completed a *general* training; and finally in 1919 after long struggles, the Nurses Registration Acts were passed, which established Nursing as a definite Profession under the jurisdiction of a General Nursing Council.[1]

Thus the tide of these new ideas was in the end too strong for Florence Nightingale's ideals, which had been such an impelling influence in Mid-Victorian days. Nevertheless they still persist beneath the professional status, and are valued by the sick more highly perhaps than technical skill, or a scientific training.

The great success of the Nightingale Training Home for Nurses at St Thomas's Hospital led to the institution of similar establishments at most of the large Hospitals in Great Britain. After a course of from two to four years' training, and a final examination, a certificate is awarded, which though it confers no legal status, is nevertheless a hall-mark of efficiency.

In the latter part of the nineteenth century, owing to the stimulus of Miss Nightingale's example, and the comparatively restricted field for women's activities, Nursing became popular as a "calling" among the class to which she belonged. The supply of well-educated candi-

[1] *Lancet*, Commission on Nursing, 1932, p. 25.

dates for a popular Training Home not infrequently exceeded the demand, and the required standard was a high one. The present century has witnessed women's suffrage, and their emancipation from the narrow outlook of former days. There is hardly any profession, or calling, nowadays which has not opened its doors, and many of them offer superior attractions and prospects to the strenuous life, discipline, and self-sacrifice which Nursing entails. Moreover, the young woman of the present day is not content with the restrictions and dedication to a vocation which were implied in the Nightingale ideal. The nursing profession has had, therefore, to compete with many other professions and callings for women, and at the same time to meet the steadily increasing demands of all the hospital and public health services.

It is not surprising, therefore, that there is a general shortage of Nurses to supply the needs of the Voluntary and Municipal Hospitals, which of late years have multiplied in number ; and of Asylums, Institutions, Private Nursing Homes, the Nursing Services, and District Nursing Associations. It is impossible to escape from the fact that Nursing in any of its many branches is not for those whose object in life is to have a " good time ", and who are not prepared to give more than they receive. And it is encouraging to hear from the Nursing Recruitment Centre (21 Cavendish Square) that the number of recruits coming forward for the nursing profession has increased steadily, and many more women are becoming student nurses than was the case a few years ago. In 1937 the number entering for the Preliminary State Examination was 9,000 ; in 1941 it had risen to well over 14,000. The need has increased in proportion, however, and various steps have had to be taken to meet the shortage.

Following the report of the Lancet Commission (1932) on the serious need for more Nurses and the recommendations for improved conditions of service and shorter hours the situation was judged sufficiently serious to call for the setting up of an Inter-Departmental Committee (known as the Athlone Committee) for the purpose of enquiring into the arrangements then in operation with regard to the recruitment, training, registration and conditions of service of nurses.

The Committee received an immense amount of evidence, and in their Interim Report, published a few months before the outbreak of war, they referred to the great urgency of the problem of maintaining an adequate nursing service for the hospitals, and to the anxiety about the problem manifested by the Public, in Parliament, and in the Press.

The keynote of the Athlone Committee's findings was that :

" The status of the nursing profession is all-important if a suitable flow of recruits is to be obtained, and the profession should be recognized by the State, the public, and the hospital authorities as a service of outstanding national importance."

From this, recommendations followed naturally enough that the salaries and pensions of nurses should be dealt with on a national basis, (since in the Committee's opinion the salaries then paid to nurses were too low and did not compare favourably with those obtaining in outside employment), and that there should be a system of grants from national funds to all recognized training hospitals in respect of the national work done by the training of nurses, as well as grants to meet the cost of the increase in salary and other essential reforms contemplated.

The Committee recognized that while great improvements had taken place in conditions of service, at the same

time conditions still existed which hindered recruitment. They regarded excessive hours of work as acting most adversely on the supply of recruits, and recommended the introduction of a 96-hour fortnight universally in hospitals. All student nurses should be given four weeks' annual leave, and should be relieved of all hospital duties for as long as possible before sitting for a State Examination. They considered that accommodation for the resident staff should be improved in a number of hospitals and that there should be an extension of the system of living out, in the case of trained staff. They commented on the deplorable effect, on those in the profession and those contemplating nursing as a career, of unreasonable rules and restrictions affecting the nurse's life, and recommended the establishment of Nurses' Representative Councils, which would remove causes of friction and give the nursing staff some voice in the administration of the hospital. The outbreak of war stopped the Committee's further work, and prevented the universal adoption of the 96-hour fortnight and other reforms recommended, but by degrees many of the Committee's recommendations were put into effect.

Perhaps the most important was the setting up by the Minister of Health of a Nurses' Salaries Committee under the chairmanship of Lord Rushcliffe to draw up agreed scales of salaries and emoluments for State Registered Nurses employed in the hospitals and in the public health services including district nursing, and for student nurses in hospitals approved as training schools. The Committee's recommendations as to salaries have now been adopted as national rates, and there is here a clear parallel with the Burnham scale for teachers. The First Report of the Athlone Committee contained recommendations that all fees for training should be abolished (it had been customary at some of the larger hospitals to

charge a small fee for the preliminary training course), that all uniform should be provided, and that as soon as conditions permitted the 96-hour fortnight should be brought into national operation, in the case of student nurses such hours to be inclusive of lectures and tutorial classes.

Another of the Athlone Committee's recommendations was implemented in 1940 by the setting up by King Edward's Hospital Fund for London of a Nursing Recruitment Service (now established at 21 Cavendish Square, W.1), some of the main functions of which would be:

(*a*) to establish effective regular contact between the hospitals and the education authorities and generally to act as a Public Relations Department for nursing;

(*b*) to develop a system whereby girls on leaving school could be "registered" and kept in touch with the hospitals;

(*c*) to supply information as to the qualifications required and facilities offered by the different hospitals and as to the prospects offered by a nursing career.

Guidance is not based mainly on the special requirements of each hospital—the aim is to secure for each candidate the best training for which she is eligible, remembering her abilities and circumstances. At the present time, the Service is entering for training some 2,000 student nurses a year, in addition to the large number who come for general information on nursing as a career but prefer to make their own arrangements.

In 1941 the Royal College of Nursing set up a Reconstruction Committee under the chairmanship of Lord Horder with the following terms of reference:

"To consider ways and means of implementing the

recommendations of the Athlone Committee on Nursing Services, and to recommend such further adjustments to the nursing services as the present situation and post-war reconstruction may demand."

The work of the Committee was divided into four sections with appropriate sub-committees to consider the following subjects :

The Assistant Nurse,
Education and Training of the Nurse,
Recruitment,
Economic Conditions.

Reports have been issued on the first three.

In March 1943 the Nurses' Act passed both Houses of Parliament, and was placed on the Statute Book. This provides for the enrolment of assistant nurses for the sick and for the regulation of agencies for the supply of nurses. It does not restrict the practice of nursing to registered nurses and enrolled assistant nurses as the Horder Report had recommended, but restricts the use of the name or title of nurse to those registered or enrolled as above, so that the public who employ totally unqualified attendants in sickness may not be in any doubt about the question.

The problem of meeting the increased demand for nurses in time of war without lowering the general standard of the profession received careful attention many months before the outbreak of war in 1939, and the demand thereafter on the Nursing Profession for war service in all its branches was so great and the response so ready that the shortage for Civilian Services which previously existed had still further been seriously accentuated.

The problem, therefore, was to find new sources from which to supplement the work of trained and student nurses, and with this object the Ministry of Health set

up the Civil Nursing Reserve, a hospital service open to three categories of recruits :

(*a*) Trained nurses not already actively engaged in nursing work.
(*b*) Assistant nurses.
(*c*) Nursing auxiliaries, comparable to V.A.D.s.

At the end of 1940 the number of nursing personnel in the Civil Nursing Reserve distributed to the various regions was :

(*a*) Trained nurses	14,764
(*b*) Assistant Nurses	7,822
(*c*) Nursing Auxiliaries	39,657

Towards the end of 1942 it became clear that additional measures were needed to deal with the overall shortage of nurses. The Minister of Labour and National Service undertook, by agreement with the Minister of Health, to deal with these problems, and the nursing, midwifery and hospital organizations agreed that the Minister's war-time powers of direction should be extended to nurses and midwives, subject to certain conditions. A National Advisory Council for the Recruitment and Distribution of Nurses and Midwives was set up by the Minister, under the chairmanship of Mr Malcolm McCorquodale, Parliamentary Secretary to the Ministry, and with the Technical Nursing Officer to the Ministry as Secretary.

It will thus be seen that, within the framework of these authoritative Committees and Organizations for the improvement of nursing conditions, any intending recruit may be assured that in future the nursing profession in its material outlook as regards hours of work, leisure, pay, and general opportunities, will bear comparison with any other career open to women. But there is something

more—something which many of these others may lack. To those for whom nursing is a real vocation, and not a mere means of earning a livelihood, the work, however hard and often disagreeable, however ill-paid and often disheartening, is of absorbing interest in itself. It is satisfying and brings happiness, and is not a machine to be escaped from as soon as possible. To be a welcomed and trusted visitor in the houses of the rich, or at the homes of the poor; to be on terms of friendship with all sorts and conditions of men; to see human nature at its best and worst; and to be a ready helper in time of trouble, are no small compensations for the hard work and responsibilities of a nurse's life, if she is inspired with those ideals which gave strength and courage to Miss Florence Nightingale.

Chapter XX

SOCIAL MEDICINE AND FUTURE OF MEDICAL PROFESSION

The issue of the Government White Paper as the result of the Beveridge Report, and the far-reaching proposals outlined in all that concerns the Health of the Nation, raises the important questions of: (1) "Social Medicine," and (2) The institution of a State Medical Service, and the future of the Medical Profession.

> We appear to be at the dawn of epoch-making changes, for together with the desire for "freedom from want, better education, assurance of employment", and "economic. stability", there are indications that the Nation is becoming "Health Minded", and anxious to co-operate in "Freedom from disease", as outlined in Mr Beveridge's *Pillars of Security* (Allen & Unwin, 1943). As Dr Ryle (Professor of Social Medicine, University of Oxford) has pointed out there are two main misconceptions about the meaning of "Social Medicine"—(*a*) It is not another name for Preventive Medicine as we now know it under the Health Authorities, and (*b*) it is not synonymous with State Medicine. Social Medicine means the tracking down of the essential causes of the vast amount of illness, debility, malnutrition, and mental disturbance and other "functional" disorders, in which there is no evidence of organic disease, but which are frequently its precursors, and which in themselves contribute so largely to national inefficiency, loss of work, general unfitness, and the making of a C3 population.

There can be no doubt that by far the greater number of these disabilities are in their origin due to faulty conditions of living, improper or insufficient food, overcrowding, inadequate housing, mental stress from economic

insecurity, and that general ignorance which so often is companion to squalor and dirt and vermin.

The majority of doctors would, I believe, agree with Professor Ryle (*B.M.J.*, Nov. 20, 1943) when he says

> Good food and habits of feeding, good houses, better facilities for open-air activities and cleanliness, better education and cultural opportunity, holidays, and social security—could they be extended to the populace as a whole—would bring benefits both human and economic to the individual and to the State, beside which those accruing from all our remarkable advances in *remedial* medicine and surgery of the last century, valuable though they have been, and must remain, would make but a poor showing.

Future of the Medical Profession

Meanwhile what part is to be taken by the Medical Profession in the Health Campaign which has already started?

It is the doctors who know best the many and various functional disorders, as well as organic diseases which originate from these social deficiencies, and the causes of which they have been powerless to alter, with the result that their education and efforts have hitherto been directed to the *treatment* of disease when already established, rather than at present to the *prevention* of its occurrence from sources additional to and outside the province of our well-organized and highly efficient Health and Sanitary Services.

The brilliant discoveries in the last fifty years of new remedies, the introduction of new instruments and techniques, the wider outlook from the enlistment of the exact Sciences in diagnosis and treatment, the necessary reliance of the "clinician" on more and more aid from the laboratory, and less and less necessity for the cultivation of *clinical* experience and insight, have tended to

alter the special characteristics associated with the older type of doctor—

> The sciences and technique have come to dominate medicine to the exclusion of the most important science of all—the science of man—and the most important technique of all—the technique of understanding. Science without humanism may work with atoms, but it will not work with man. (Professor Ryle.)

These wise words express the undercurrent of feeling in the minds of many of our ablest Clinicians that the scientific side of Medical Education is tending to submerge the humanistic, viz., the personal interest of a student in the patient himself, his work, family, anxieties and troubles, his mental make-up. An understanding and sympathetic attitude in these friendly relationships will go far to help a patient through his illness, and form a more lasting impression than the thoroughness of the examination to which his members are being subjected, or of the investigation of his germs and bodily fluids in the laboratories.

There were great advantages in the old system of apprenticeship under which a student had to spend part of his curriculum in the service of a practitioner—In this way he was brought into intimate contact with the homes and surroundings of his patients, and gained that information about the beginning of disorders which it is now realized are of such great importance.

It might be worth considering in any reformation of the Medical Curriculum whether some such scheme could be introduced—e.g. *after* qualification but *before* a degree or licence was finally conferred, a two or three months' residence with a practitioner, or State doctor, as an assistant.

The Medical Profession—perhaps the most conservative of all professions—is becoming alive to the necessity

of reform of outlook, and to a more liberal interpretation of its curriculum of education, if it is to take up the important position it should occupy in national reconstruction, and at the same time conserve what is most precious in its traditions.

The somewhat alarming proposition of the creation of a comprehensive State Medical Service for everyone of all classes, and which would include the managing and financing of Hospitals, Asylums, Sanatoria, Rehabilitation Centres, and other Health Institutions, as well as treatment in the homes, and the consequent almost total abolition of Private practice and the existing Voluntary System for Hospitals, is causing no little perturbation in all branches of the Medical Profession, both as to the future outlook, and the attitude it should adopt towards the proposal.

It is realized that reforms are badly needed in the curricula and training of medical students, that the social problems which are largely concerned with the *origin* of diseases and disabilities have been neglected, and that private practice under the present National Insurance Scheme is far from satisfactory, and has lost much of its attraction.

It can hardly be doubted that while affording a more stable livelihood, the "Panel" with its laborious certificate signing and reports which absorb so much time and detract from careful examination of patients, and the easy way out of sending off difficult cases for "Hospital treatment" and thereby avoiding responsibility has tended to diminish the self-reliance and competency of the practitioner.

The type of the old doctor who dealt, and as a rule successfully, with the majority of diseases and accidents off his own bat, and was an expert in midwifery, has altered and not always for the better. The Panel doctor

still possesses, however, the priceless privilege of the "Family" Practitioner—contact with the human side of his patient, his family and surroundings, his anxieties, joys and sorrows, and he not infrequently becomes the friend and counsellor of succeeding generations.

How this tradition can be preserved under State Medical Service remains to be seen, but it should not be impossible, if the principles of (1) Free choice of doctor by patient, and (2) Individual responsibility and care of his quota of patients by the doctor, can be preserved. No sense of "officialism" must be allowed to disturb these intimate relationships, and misfits could be more smoothly adjusted than is often the case in private practice, where rivalry may be a source of bitterness.

With these conditions as fundamental, the attraction of economic security, every facility for diagnosis and treatment from laboratories and hospitals, and the aid of consultants and specialists, in their work, may well appeal to the younger men of the profession, after their experience of War Service—and to these advantages may be added (1) More time for rest, recreation, and holidays, (2) The prospect of "refresher" courses to keep abreast with advances, or learn a speciality, and (3) The sense that he is working with colleagues and not, as in the past and present, against rivals.

A very important requirement, if a State Medical Service comes into being and is to work smoothly, is that all that appertains to the organization, equipment, and management of the *technical* side in Hospitals and Institutions—the general lay-out in fact—should be in the hands of the doctors themselves; and this applies as well to the chief voice in the selection of the Hospital Staff; and they should also be strongly represented on lay Committees created by Local Authorities to represent the interests of the public and patients, and to deal with

finance, building, and co-operation of existing or future Institutions within the particular area or zone of Hospital Service.

No success of any such Scheme can be expected if there are manifest sources of friction between doctors and laymen.

Venereal Diseases

Attention has been called to the fact that in the first edition of this book no allusion was made to the subject of Venereal Diseases—Syphilis and Gonorrhœa—which have such an important bearing on national health and efficiency.

Since the discovery of the cause of Syphilis, a protozoal micro-organism—the Spirochætum Pallidum—in the blood and tissues, and the later discovery of efficient treatment by arsenical compounds—and in the case of gonorrhœa (caused by gonococcus) by the Sulphonamides or Penicillin, these appalling diseases, which for generations have sapped the vitality of the white races, and by them introduced with disastrous results to hitherto untainted native races, are now known to be both preventable and curable if we will take the means and have the will to stamp the mout (see also Chapter XIII, " Chemotherapy ".

The subject is too controversial to be discussed here at length, but briefly there are two aspects from the Social point of view—(1) the moral and educational; (2) the physical; each of which has its extreme advocates in regard to prevention and cure, while probably (3) the majority of people take the common-sense point of view and wish to enlist both these agencies in the control and eradication of these blots on civilization.

As mentioned in Chapter XIII the cruellest features of

Syphilis are its long continuance in the system, often for life, and its congenital transmission.

The extreme Moralists take the view that the former feature is both a punishment for and a deterrent of the commission of a grievous sin—and the latter (congenital Syphilis) a verification of the second commandment—(" the sins of the fathers ") ; surely a too heavy retribution for the temporary loss of control of a natural and ordained passion when properly regulated, but which in some natures becomes very difficult to restrain, especially when under the influence of alcoholic excitement. The pagan and possibly the average man may feel with King Lear " The gods are just, and of our pleasant vices make instruments to plague us."

The great majority of doctors, and the common-sense folk would probably place these preventable diseases in the same category as tubercle and rickets, but more preventable by precaution or direct treatment at their inception, and in subsequent stages.

The moral aspect should be a primary feature of our upbringing at home and at school, by open instruction and private counsel, with no diffidence, or atmosphere of " hush hush ", or fear of the light. How much greater would be the charitable outlook if the moral extremists on this question—(which has its analogues in the opposition in the use of chloroform at childbirth (page 44) would take the view that a just and beneficent Creator has given us through Science a means of mitigating the physical punishment of our sins, while their commission would still remain a permanent and heavy burden on our conscience.

The less serious, but more common venereal disease gonorrhœa—due to the gonococcus—gives rise to a vast amount of disability in its early stages, while later on it is a frequent cause of a crippling arthritis of the joints,

or by damage done to the genito-urinary organs is a not infrequent cause of sterility in the female, or stricture in the male.

By neglect or ignorance the complaint frequently becomes chronic and was most difficult to cure by the remedies and treatment formerly employed.

Both the sulphonamides and penicillin are highly lethal to the gonococcus, and if early treatment is given the complaint can be quickly cured by a few weeks of careful treatment—followed by occasional tests, and another short course if necessary.

The loss of time and labour caused by this disability is immense, and as with Syphilis, moral and educative influence should work hand in hand with medical treatment to diminish this pestilent scourge.

The establishment of Treatment Centres for Venereal Diseases all over the United Kingdom has already been a great social advance, and so too the Notification Act for Syphilis—in spite of the difficulties arising from concealment which vitiate reliance on statistics.

However, in illustration of the diminution of Syphilis as estimated by the numbers applying for treatment—

In 1920—42,000 applied at Treatment Centres
" 1933—21,000 " " "

Congenital Syphilis in 1917, 2·03 per 1,000 of total births
" 1933, 0·40 " " "
(Ven. Diseases Act 1917, Vol I—20 edit.)

The diminution and cure of these diseases are in the hands of the people and the victims themselves.

Maternal Mortality. The steady decrease in maternal mortality will be realized by the table below. Previous to 1937 it was approximately 5 per 1,000. The decrease is largely due to the establishment of Ante-Natal Clinics

Vital Statistics

Population approximately 41,000,000

	Birth rate. Total births.	Birth rate. Rate per 1,000.	Death rate. Total deaths.	Death rate. Rate per 1,000.
1940 . . .	607,000	14·6	581,000	14·0
1941 . . .	587,000	14·2	535,000	12·9
1942 . . .	654,000	15·8	480,000	11·6

to the number of 1,798, and at which no less than 385,000 expectant mothers attended 1938–40—and also to the introduction of the Sulphonamides in the treatment of puerperal sepsis.

Maternal Mortality—per 1,000 births.

	Infection.	Other Causes.	Total.
1940 . . .	0·79	1·81	2·60
1941 . . .	0·82	1·94	2·76
1942 . . .	0·77	1·70	2·47 (lowest recorded)

Infant Mortality under one year also shows a satisfactory reduction, due largely to the establishment and popularity of Infant Welfare and Clinics; and better education of the mothers.

In 1896–1900 of every 1,000 children born alive, 156 on the average died during the first year.

	Total deaths first year
In 1931 the rate was 66 per 1,000 births . . .	41,939
„ 1940 „ 56 „ . . .	33,892
„ 1941 „ 59 „ . . .	34,550
„ 1942 „ 49 „ . . .	32,257

These figures show a steady decline in infant mortality, but it is disturbing to find, without going into somewhat

complicated statistics, that the proportionate rate among the poorer classes is far greater than in those of a higher and more prosperous social grade.

Tubercular Mortality from all varieties.

	Total.	Rate per 1,000.
In 1901–10	55,000	—
1935	29,201	—
1940	28,000	0·679
1941	28,000	0·692
1942	25,000	0·616

A slow but far from sufficient rate of decline with our present knowledge, and means at our disposal.

Cancer	Total deaths
1940	69,000
1941	69,000
1942	70,000

Stationary or slightly on increase—awaits further research and meanwhile earlier diagnosis and treatment is the chief resource.

Chapter XXI

THE ROMANCE OF MEDICINE

To the unimaginative there is probably no subject less entitled to be called romantic than the story of man's conflict with disease. What place is there for romance in the tale of his long history of effort to annihilate myths, superstitions, and beliefs, which have obstructed the path of progress, and to construct in their place a way to truth founded on observation, experiment, and accumulated facts? The principles of Medicine are based on reason rather than on imagination. Nevertheless there is a spell in the lives and discoveries of its great figure-heads, which extends into the daily routine of the humblest practitioner and infuses with glamour the activities in every department of a Hospital. A career in Medicine or Nursing is generally adopted as a means of earning a livelihood; yet to the least imaginative aspirant it must sometimes occur that he (or she) has embarked on a voyage of adventure, and that the knowledge to be gained by a student is not limited to the bare accumulation of facts.

A new world comes into being when for the first time the circulation of the blood in the web of a frog's foot is seen under the microscope; or when the wonderful construction of the human hand is laid bare in the dissecting room; or when through an ophthalmoscope the chamber of the eye is revealed in all its beauty.

He would possess a dull vision who sees nothing more than an object on a slide, when he gazes at life at its beginning; first as a single cell with all its inherited potentialities, followed by its countless divisions and sub-

divisions which build up the complex structure of the specialized tissues, each one of them taking its allotted part in the formation and functions of the completed body. He may call to mind the 139th Psalm, "For I am fearfully and wonderfully made. Thine eyes did see my substance yet being imperfect, and in thy book were all my members written, which day by day were fashioned, when as yet there was none of them." His wonder is not lessened when he sees that at one period of his existence he possessed the gills of a tadpole and the tail of a quadruped. In his Preliminary Studies, whether it be Anatomy, Physiology, Biology or Chemistry, the medical student, if he will, may find a fairy land of Science, and not merely a colourless list of names, memoranda, and classifications to be learnt by heart for his examinations. He will have lost all the pleasures of fancy if his vision is limited to materials, and facts, or if he resembles the Botanist to whom (with apologies to Wordsworth) :

> A primrose by a river's brim
> A "Dicotyledon" was to him
> And it was nothing more.

Another world awaits him when he begins his "clinical" work, and enters the wards of a hospital, to learn about the diseases and accidents which destroy and distort the organs whose structure and functions in health he has already studied. And here at once apart from Science, apart from Pathology (the study of disease), a further interest enters his horizon. The human element creeps in. See "Social Medicine" page 250. Henceforward this has to be taken into account. He is introduced to pain and suffering ; the distress and anxieties of relatives ; the loss of the breadwinner ; what a parent means to a child, or a baby to a parent. He is brought into contact with the lives of classes not his own, and learns

that the " Colonel's lady and Judy O'Grady are sisters under their skin ". He notes as not unworthy of example the fortitude that can be shown in agony and the fear of death, by the urchin run over in the street, or the porter crushed between the buffers ; and the patience and calm of a woman suffering from a long-drawn-out and hopeless malady ; and he becomes assured that death itself generally comes as a welcome relief, and is not attended by the suffering and terror so often portrayed in fiction. He learns in taking the history of an illness how to distinguish the important facts in a mass of irrelevant detail ; how to sift the grain from the chaff ; how gentleness of hand and sympathy are the quickest way of winning confidence ; and how an unruffled demeanour leads to mastery of the situation in the confusion of an emergency. At the bedside he becomes expert in the use of the marvellous instruments which mechanical ingenuity has given to Medicine, such as the stethoscope, laryngoscope, ophthalmoscope ; he peeps into the illuminated recesses of internal organs, and with the cardiograph watches the heart recording its rhythm. In the laboratories he will learn with microscope and test tube how to cultivate and recognize the many and various germs of disease, to take a census of the different corpuscles in the blood, and analyze the secretions and excretions of the body.

After numberless examinations comes his final qualification as a doctor, and if he has done well in his academic career he may gain an appointment as House Physician or Surgeon in his own or at some other Hospital ; a post requiring no little judgment and self-confidence, and in which he will taste the bitters and sweets of responsibility. The work is so strenuous, the daily routine so exacting, that there is no time for daydreams. But sometimes as he pays his last visit at night to a ward,

when everything is still and quiet, and only dimly outlined by the shaded light at which a nurse is writing her report, the weirdness of it all may have the effect of an illusion. The rows of beds with sleeping patients ; the cot where a baby is resting on its head and knees ; the distressful gasping of a heart-case, sitting upright ; the muttering incoherences of one in delirium, call up a crowd of conflicting emotions. The ward looks so calm and restful, so cosy and so trim, yet each bed bears a weight of suffering and care ; each occupant is relying on doctor and nurse who are only too conscious of their limitations. The contrast with his own life, so well, so vigorous, so full of hope and ambition for the future ; the thought that one day it may well be his own lot to lie helpless, and trusting to another's skill, oppresses like a weight, and for a moment reality destroys the romance he has been weaving round his work, as the eternal *why*, and *whence* of pain and suffering come uppermost in his mind.

It may be the reaction from a merry supper party, or the depressing influence of a too seriously minded night-nurse that gives rise to such morbid sensations during a night round. But whatever the cause, morning sees a return of all his buoyancy, for his heart is in his work, and his only care is the thought that one day he will have to say farewell to the old Hospital, which has inspired him with its traditions, taught him his profession, and brought him lasting friendships.

The inevitable day arrives, and sooner or later a choice must be made of one of the many branches of the profession. The range is a wide one, for there is no calling which offers such a variety of openings.

If his decision falls on private practice, a further choice must be made between the taking up of a special subject, securing a staff or teaching appointment at a hospital

and practising as a Consultant, or joining the humbler ranks in General Practice. A number of men prefer to enter Government employment in the Navy, Army, or Air Forces, or obtain civilian posts in one or other of the Public Health Departments, such as the Sanitary Service, School Clinics, Asylums, or Infirmaries. Abroad there are Colonial appointments, and other openings in salaried billets or private practice. Some with a call for the sea spend their lives as doctors in a branch of the merchant service, others from religious motives become medical missionaries. Beside these there are other opportunities for foreign travel. Nearly every expedition or mission, whether for exploration, scientific, or other purposes, requires a doctor as one of the company, and the success of the venture depends not a little on his capability and resource. Failure or disaster may be the occasion for sharing in deeds of heroism like those of Captain Scott's expedition to the South Pole, in which Dr Wilson took so prominent a part, dying with his companions at their last bivouac. In times of war in any country the Red Cross affords scope for the highest expression of daring and service. A splendid example was afforded by young Dr John Melly in the late Italo-Abyssinian War. In the Great War, at the age of seventeen, he won the Military Cross for bravery; at Oxford he won his "Blue" for boxing. At his Hospital (Bart's), he was beloved for his gaiety and debonair manner, though beneath them lay the spirit of a crusader and deep religious feeling. When war broke out his mission in Abyssinia had hardly begun, and in serving under the Red Cross he sacrificed his life by delaying his escape in order to succour a wounded Ethiopian.

Moreover many who have no inclination for the practice of their profession and find their interest in its science, become demonstrators or professors in the medical schools

and Universities, and seek fame, but seldom find fortunes, in research. It is owing to their work that the great advances of Medicine have been made; for although it is a curious and interesting fact that many of the greatest discoveries that have left their mark on Medicine have been made outside the ranks of the profession—for example, by Pasteur, Röntgen, Madame Curie—the adaptation of these discoveries to the treatment of disease is due to the insight of the physician, or his colleague in the laboratory. Within their ranks must be numbered the great anatomists, physiologists, pathologists and bacteriologists, whose names are barely known to the layman, but who have transformed Medicine from a cult into a science. In whichever branch our student eventually finds himself, the gift of imagination will bring a touch of romance to work which is seldom dull or uninspiring, and a sense of humour will carry him through situations which make a big demand on his patience or temper.

In this respect the research worker has the greater advantage. He is engaged on a quest, and the wonders which fired his imagination in his student days attend him throughout life. His quest may be successful or not, but it has been full of adventure, and if he fails in attaining his object, his labours have helped to clear the way for others. Nor is his work devoid of human interest. The contact with successive generations of students keeps him fresh and abreast with the times, for there is no better broom for keeping off the dust than the sweeping criticism of younger minds. But the majority engage in the active practice of their profession in one or other of its many branches, and the human interest here at any rate is never wanting. "An apple a day keeps the doctor away" may be a sane though not necessarily a truthful maxim; and while it may suggest that his

absence is more to be desired than his presence, nevertheless, when he arrives, his peculiar position as friend, adviser, healer, and consoler, assures a welcome which is hardly enjoyed by any other calling. In none are there such opportunities for entering into the intimacies of personal and family life.

The Court Physician in a palace, and the country practitioner at a gypsy caravan, become familiar with aspects of life which are only unveiled to a trustworthy confidant ; to one who is ever mindful of his loyalty to that enjoinder in the oath of Hippocrates—his profession of faith—which declares : " —And into whatever houses I enter I will enter into them for the benefit of the sufferers, departing from all wilful injustice and destructiveness, and all lustful works, on bodies male and female, free and slaves. And whatever, in practice, I see or hear, or even outside practice, which it is not right should be told abroad, I will be silent, counting as unsaid what was said."

In distant countries among foreign races, alien to his own in tradition, religion, and social habits, the prejudices of caste, and the jealously guarded secrets of tribal customs are no bar to the admission of the doctor on his errand of healing. The ethnologist finds it easier to probe the obscurities of savage ritual, and the mysteries of taboo ; the missionary to win souls ; if, with the additional qualification of doctor, they have first brought relief to the ills of the body.

In the consulting room of the " Specialist ", or in the daily round of the General Practitioner, there is never wanting something out of the way, something curious, be it sad, or humorous, which clouds or brightens the vista of life, and gives a zest to work. As I have said, a doctor must possess the gift of sympathy and a sense of humour before he can appreciate to the full the

invaluable opportunities they afford, of getting an insight into the lives and mentality of the many extraordinary people he will encounter. A doctor is continually asked to believe incredible stories or perform impossible tasks; but a calm face in the one, and an air of omnipotence in the other will often carry him through an embarrassing situation. The relation of one or two quite trivial incidents in illustration will hardly be considered a violation of the Hippocratic oath, for they occurred many years ago, and the other actors have long since vanished.

One day a lady brought into my consulting room a box which on being opened was found to contain a chameleon. The creature she said was "off colour" and having no faith in "vets" and in her own experience some knowledge of my skill, she had brought it along to see what I could do. I had no acquaintance with the internal arrangements of chameleons, but managed to conceal my embarrassment, and tried unsuccessfully to make it put out its tongue. The stethoscope also drew a blank, and in despair the usual formula (when in doubt) of a "change of air" appeared to offer the best chance of a cure. However, before resort was made to the South Coast (a highly welcomed suggestion) I advised—(1) starvation for twenty-four hours; (2) the first meal to consist of a fly lightly dipped in castor oil. The advice was followed, the chameleon regained its loss of tone, and I added to my reputation.

It is remarkable how excessive credulity, and a total lack of scientific discrimination may be found in some people (especially when they are anxious about friends or relatives) who in other respects possess intellectual gifts of a high order.

I had been treating unsuccessfully a boy of thirteen for the distressing complaint of bed-wetting which is generally considered a bar to entrance at a boarding

school. The mother was an "intellectual", artistic in temperament, and a capable manager of her home and family. The boy was being educated at home, but the time had now come when he had to go to a public school. His case was one which did not require frequent attention, and it was not for some weeks on a chance visit that I learnt that he had been "cured" of his disorder and was happily installed at —— College. Naturally I enquired about the remedy which had wrought such astonishing results in so short a time. My enquiries were received with some confusion, and a decided reluctance to give the details "in case they should be laughed at". After protesting my seriousness, and the benefit that might be conferred on others, the story came out. A friend had told her of the remedy. "A brown mouse must be caught, dressed, cooked, and given at supper time to one thus afflicted, and a repetition was hardly ever necessary." "But" (I said) "did he know he was eating a *mouse*?" "Don't be silly, Doctor," the mother replied. "You know what Tommy is, he wouldn't have taken it, so we said it was a *lark*." "And how long was it before improvement was noticed?" "Amost immediately; after a very few nights we had no more trouble." With all due gravity I thanked her for the information, and later on added "brown mouse" to my pharmacopœia. Note "brown". House mice are grey in colour, and a brown mouse (probably a field vole) is difficult to obtain. The difficulty in getting many of the ancient remedies must have added greatly to their efficacy, but in this case the boy thought he was eating *lark*, and his cure could not have been psychological. The simple explanation, of course, lies in the fact that this particular disorder nearly always ceases more or less rapidly at about his age. But not for worlds would I have trampled heavily on such a pleasing superstition

which recalled the days of medical nostrums and medieval bestiaries.

Other occasions could not always be met with equanimity. Once I was called to the aid of a spinster lady, presumably for illness, but found on my arrival that mental agitation was the cause of the distemper. A row had occurred with the cook, and the lady wished to discharge her at once but could not face the music; would I undertake the task? At a former interview I had dealt with this domestic worker for some minor complaint, and had no desire to renew the acquaintance. Nevertheless, I was urging myself on when I suddenly remembered a call to an accident which had been forgotten, and hurried away with promises of a speedy return. Curiously enough this promise was also forgotten, but when I returned the next day, to make my apologies, things had settled down and domestic calm again prevailed!

Trivial as such incidents may appear when they are described, their occurrence brings a lot of fun into a doctor's life and are a counterpoise to the constant responsibilities and worries which weigh so heavily on his shoulders. For a doctor lives in the atmosphere of anxiety which surrounds patients and their relatives; he is conscious of mistakes, and never free from the thought that he might have done better; and he often has to deal with people who are ignorant of his difficulties and expect more than he is able to give.

Notwithstanding the burden, it is well worth the while. The gratitude and loyalty of patients; the formation of friendships; the admission to a share of all the sorrows and joys of family life, more than compensate for the hard knocks and disappointments. It counts for something to have brought babies into the world, to have shepherded them in their childhood, and afterwards to watch them grow up, marry, and renew the cycle of birth; or to have

shared in the ordeal of a family group gathered round a bedside, and bent the head in reply to a whispered appeal.

Every young man, or woman, who is thinking of taking up Medicine as a profession, and wishes to learn something of its philosophical aspects should read Sir Thomas Browne's *Religio Medici* ; Sir William Osler's *Aequanimitas*, and a charming little book by Stephen Paget, *Confessio Medici*. In these fine writings are gathered the reflections and counsels of very wise and lofty minds, and no sounder precepts can be found to serve as guides, philosophers and friends in difficulties, than exist in their pages. Personal experience, however, is better than precept, and any doctor should consider himself fortunate if he himself has been a patient and knows what illness means, and is able to appreciate the full value of sympathy and tender dealing. One who carries these with him, possesses a magic apart from his medicines, for when the latter fail he has further resources than

> To shake the sapient head, and give
> The ills he cannot cure a name.

A few lines must be devoted here to the layman's, or patient's point of view. Is there any place for fancy, or the pleasures of imagination, when illness brings them "under the doctor" either at home or in hospital? We must leave out those to whom illness is the chief interest and occupation of their lives, and the craving for sympathy a ruling passion ; with such people fancy is already exaggerated and they not infrequently find a romance in Medicine that is morbid and extravagant, and the indication of a disordered mind. Omitting these unfortunates, the experience of an illness, and the contact with doctors and nurses, in the sickroom, or in the strange surroundings of a hospital, are not to be estimated only by the physical discomforts of body and the unwelcome discipline of

treatment. There are many to whom such an experience will bring a new vision, transcending their usual preoccupations and the drabness or drudgery of daily routine. Hospitals are no longer the dreaded last resorts of the afflicted, holding out prospects of infection, torture, dirt, and neglect. Nowadays the brightness of the surroundings, the good appointments and food, the cleanliness and order, the comfort of skilled attention, the cheeriness and goodwill which prevail everywhere, make a stay in hospital a bright interlude in the lives of many patients, and a happy incident in their memories.

In fact, we have another godmother besides the one attendant on suffering, as any child will tell you in a ward at Christmas, or on the open-air balconies at Alton ; and to many children her first visit has been paid in a hospital.

CHAPTER XXII

EPILOGUE

FINALLY, what can we expect of Medicine in the years ahead? Let us for a moment try to anticipate. One presumption seems certain. The future of Medicine will lie chiefly in prevention, and there will be less necessity for reliance on treatment and cures. Treatment of every kind will be founded on rational principles, in imitation of Nature's methods, or with the aid of agencies and remedies gathered from the exact branches of Science. The bill for the sixty or more million prescriptions which were issued under National Health Insurance practice in 1934, amounting to £2,100,000,[1] will probably be less heavy in days to come, and nobody will grudge spending the balance on better food, better housing, and physical training, which will do more for health than swallowing a combination of drugs " three times a day ".

Doctors are sometimes taunted for not having discovered, with all the advantages of Science, a means of preventing or curing a number of common complaints; for example, colds, influenza, chronic rheumatism, cancer. It is precisely in such common disorders that the greatest difficulties have been encountered in discovering the cause, and further refinements in the methods of research must come before these problems can be solved.

The researches on Virus infections and diseases already have opened a fruitful prospect in regard to the prevention and treatment of such common complaints as colds, influenza, measles and many others, e.g. chronic rheu-

[1] Speech by Minister of Health at National Association of Insurance Companies, Bournemouth, October 1936.

matism, that crippling disorder, the bugbear of middle and old age, which wrecks so many lives and fills our health resorts with patients still hopeful, and anxious to try the latest " cure ", is the subject of special study at Centres under the ægis of Lord Horder.

On the other hand, too little attention is given to the knowledge we already possess. Our knowledge of the causes and means of prevention of many diseases which swell the death rate, and of a host of others, which, though not dangerous, are sources of disablement, far exceeds our ability to cope with them. Our efforts are hindered on one side by ignorance, and a dislike of interference on the part of the public, and on the other by the hostility of vested interests, or the economic and political caution of legislators, e.g. the necessity for the pasteurization of milk.

Try to imagine some ideal State of the future where these considerations have long ceased to apply ; where huge expenditure on armaments has been diverted to the improvement of health and the standard of living ; where, in addition, this change has been rendered possible by the education of the people in some of the elementary facts of Science. The general public, then, would no longer pin its faith in sickness to bottles of medicine, or quack remedies, but would regard the restrictions and precautions of the Health Authorities as the best assurance against disease.

Many of the recommendations of the Beveridge Report would go far to remedy this state of affairs, and encourage a health-minded and better instructed public in hygiene, and the prevention of diseases at their source.

Smallpox, for instance, would become a thing of the past, for the Government would be forced by the *will* of the people to reintroduce compulsory vaccination in infancy,

and additional re-vaccination in after years. In the event of a serious epidemic breaking out at the present time, although the means of prevention are known, it would be found that half the babies and a large part of the population are unprotected.

Tubercular disease would seldom be met with, and its occurrence in any district would be considered a stigma on the Medical Officer of Health. Reports of the Ministry of Health in 1935 show a total mortality of 29,201 from this disease—a notable decline from the rate (55,000) in the early years of the century (1901–10),[1] yet, in spite of advances made in early diagnosis, and the knowledge that its conveyance is by infection, only half-hearted measures are still adopted to segregate patients, or to eliminate the risk from milk by pasteurization, and the compulsory destruction of tubercular cattle.

It is curious to reflect that at the present time whole herds of swine and other animals are slaughtered to arrest diseases peculiar to themselves, and yet objections are raised to such a procedure in an infection conveyed by cattle to human beings.

It is still more curious that elaborate and expensive Sanatoria exist for the treatment of tubercular disease, but that patients, in order to make room for others or by their own wish, are allowed to leave before the cure is complete and return to their homes where, very possibly, they may convey the infection to their families.

The recent introduction of "Mass radiography" of the lungs as a routine procedure in all suspected of tubercular trouble, especially in children and young adults, is a great advance in its early diagnosis.

In the ideal State we have in view, and with the knowledge we already possess, it should be possible to abolish tubercular diseases entirely, along with deficiency diseases

[1] For later statistics, see Chapter XX, "Social Medicine".

such as rickets, and even the scourge of venereal diseases. (See Chapters XIII and XX).

Is fancy soaring too high if we include mental disorders, at any rate those that are hereditary? Nevertheless, there is food for thought in the Government Reports of 1934 which show that there were no less than 106,419 mentally defective citizens, known to the Authorities in England and Wales, in addition to a large number not officially recognized, and that at present there are no restrictions to prevent the transmission of their mental deficiencies to following generations.

In hereditary disorders, too, must be included a number of disabilities such as hæmophilia (bleeding disease), congenital blindness, deformities, and others, that run in families and recur in descendants. The Science of Heredity (Mendelism), however, is leading to an exact knowledge of how they are transmitted, and the laws by which they are governed.

Further examples are needless. For in those just mentioned, and in others, doctors have an adequate retort to the reproach that they have not found a cure, for example, for the common cold. The retort might well be: "That may be so, but at any rate we on our side have to await the development of an enlightened public opinion before we can carry out preventive measures which would assuredly stamp out disorders far more disastrous to national well-being than a catarrh."

Turning from diseases and disorders, let our vision extend to general health and physique—national fitness, in fact.

In the first place, malnutrition would not be tolerated, especially during childhood, in the State we are contemplating. As we have remarked, the balance saved on medicines, armaments, or other hindrances to progress, would be diverted to mental and physical culture, better

food, healthier houses, wider playing fields ; to all that brings joy to life.[1]

After two or three generations under such conditions how astonished a citizen would be to read in the *Report of the Health of the Army* for 1933–4, under " Recruits " : Of 47,392 *coming under medical examination*, 16,935 were rejected as unfit, viz., about 35 per cent. In addition, 22,392 were rejected *on sight* by the recruiting staff (non-medical). The general summary concludes : " Thus at a rough estimate, out of nearly 80,000 presenting themselves for enlistment, some 42,000, or 52 per cent., were rejected for medical and physical reasons, notwithstanding a lowering of army physical standards in the hope of securing the desired number of recruits."

Under this reduced standard a *minimum* weight of 112 lbs. only is required.

Such a citizen would have been born into a world with other conceptions than ours. More than we do he would realize that in certain respects he is master of his fate, and with a wider control of natural forces he would have made some advance in controlling himself, and in handing down an unimpaired heritage to others. Without any loss of dignity he would be using the knowledge, long since applied to the improvement of plants, and the betterment of flocks and herds, to his own culture ; for in this State the main principles of eugenics would have come to stay, and the ideas of the " farmyard " school, formerly so derided, would not longer be laughed at.

Let us return for a moment to objects more within our

[1] Since the above was written a good beginning has already been made in the provision of milk and meals at elementary schools and in the establishment of Welfare Centres where mothers can take their infants and young children for advice as to general upbringing and correct feeding and clothing, and minor complaints treated by doctors and nurses. And the scheme outlined in the Beveridge Report, if adopted, should go far to ensure in the future better living conditions for the whole population, and a higher standard of national physique and fitness.

horizon. For instance, in the coming years what may be expected from bacteriology, biochemistry and chemotherapy—the most fruitful fields for medical research? Take, for example (as shown by the Reports of the Registrar-General) the three commonest causes of mortality, heart disease, cancer, and diseases of the respiratory organs. Acute rheumatism, and chorea (St. Vitus's Dance) are responsible for the majority of heart affections occurring in children and young adults, and they are frequently the cause of permanent disablement where they are not fatal. It has been computed that eight out of every thousand elementary school children have heart disease of rheumatic origin.[1] This complaint is commoner among the poorer classes, living in damp, sunless houses, lacking in general hygiene, and where the children consequently are wanting in stamina. Improved hygienic conditions would lessen the liability to an attack, but the bacteriologists are already on the trail of the germ or germs which are the real cause, and once these are known, means may be found to prevent, or a vaccine or anti-toxin invented to counteract, the disease.

Again, may we not expect that before very long the specific cause of cancer will be discovered—a discovery which more than any other would realize the ambition of the research worker? At present it looks like a race between the bacteriologist and the biochemist on different tracks. Will the cause be found in some elusive parasite, virus, or enzyme, or in some vice of the cell mechanism itself, or of a controlling "hormone" or other principle, whereby the normal growth and function of the cell are disturbed? Meanwhile, with an earlier resort to the surgeon, or to the radiologist, we may anticipate a still higher percentage of cures, and in incurable cases a still greater mitigation of pain and suffering. In this respect

[1] Wyndham Lloyd, op. cit., p. 306.

the "Cancer Campaign" is doing excellent work in stressing the importance of seeking early advice and diagnosis.

Respiratory diseases which exact such a heavy toll are to a great extent caused by our damp climate, and are unavoidable. Nevertheless, the smoke and fumes of our large industrial towns are additional factors which could be prohibited in the future if further developments take place in the use of smokeless fuel. Preventive medicine also has not yet completed the conquest of various respiratory dust diseases, in mines, factories, and workshops.

Consider, too, what a tragic disease pneumonia is, coming like a thunder-clap, so sudden and acute in its onset that we are taken unawares, and have hardly time to bring into action the ineffective weapons we now possess, before, for better or worse, it is over and gone. If it is for the better, we must thank Nature, and not congratulate ourselves for the cure.[1] We may expect also further developments in the detection of *liability* to certain diseases, and the use of agents to confer immunity against them. In diphtheria and scarlet fever these measures have proved to be effective, and are already in practice in epidemics, and where, as with nurses and employés in hospitals, there is a special risk among those who are not *naturally* immune.

And what has the future in store for the Hospitals? The subject is far too debatable to be discussed here, but there is good reason to suppose that they will be considerably increased in number. For, although the incidence of disease will be less in a healthier population, nearly all complaints, except trivial ones, will be treated in Institu-

[1] The whole outlook in acute lobar pneumonia has altered since the coming of the Sulphonamides, and more especially the treatment of this infection by Sulphapyridine, M. & B. 693. (See Chapter XIII.)

tions rather than at home. Even the simplest maladies often require technical investigations, or specialized treatment, which can only be carried out in surroundings which provide laboratories, appliances, and a highly trained staff.

Will the Voluntary System continue? Here we are on debatable ground, but I venture to believe that it will, in spite of a considerable body of opinion that all Hospitals and other Institutions concerned with Health should be embodied in a State Medical Service; and the Beveridge Report seems to envisage such a possibility. But in spite of the glamour of innovation, would it not be little short of disastrous to sweep away many of our old-established metropolitan and provincial voluntary hospitals, under their own management, and with their long traditions and splendid record of work and eminent names associated with their history? They are rooted in the affection of the people they serve, and cherished by the doctors in every branch of their profession, and in all parts of the world who have been trained in their Medical Schools.

Moreover, Voluntary Service enters so much into our national genius, which prefers variety and individual effort to the stereotyped patterns of State management, and we find as well in the appeals of hospitals one of the chief objects which call for the outflow of our charity (in its best sense) and benevolence, and bring a personal relationship and interest.

Nevertheless, if the Voluntary System is to survive a remedy must be found for the overlapping, competition, and economic waste which often occur with independent institutions such as exist at present.

Surely it should be possible to co-ordinate State or Municipal Hospitals with the Voluntary in every district and town, each fulfilling its own special purposes, with mutual representatives on their Boards of Management

and Hospital Staffs, and each taking its appropriate part in Medical Education, teaching and clinical facilities.

In almost every district or large town, co-ordination between the various hospitals within its respective area is badly needed, and a Central Council representative of the different Boards of Management might very well fulfil this purpose and exercise at the same time a certain amount of control. To such a Council it might be well to delegate the collection and distribution of voluntary contributions and benefactions, after the model of King Edward's Hospital Fund for London.

Instituted in 1897 in commemoration of Queen Victoria's Diamond Jubilee, this splendid organization, with its remarkable capacity for administration, has for many years inspired a general confidence that benevolence towards London hospitals can be wisely exercised in its support. To every hospital within its area of action funds are allocated in proportion to its needs, and standard of efficiency. Moreover, a uniform system of keeping accounts among the hospitals gives valuable information about their financial position and economy of management.

This confidence is clearly shown by the ability of the Fund to distribute sums averaging £300,000 per annum among the hospitals in and around London. With this example, what is there to prevent each County, large City or district having a similar organization ?[1]

We have anticipated more than enough, and it is time to make an end, for in embarking upon social and economic topics I may perhaps be accused of overstepping

[1] Since the above was written the report of the Voluntary Hospitals Commission, of which Lord Sankey was Chairman, was issued on April 29th, 1937. The recommendations, if adopted, would very largely carry out the ideas envisaged above, since " the foundation of the proposals is a complete system of hospital association based on voluntary agreement ", with regional councils, and a central co-ordinating Council in London. (*Vide The Times*, April 30th, 1937.)

the mark. My excuse must rest on the probability that Medicine in the future will be concerned to an increasing extent with social and other questions in their relation to national welfare. As Dr Wyndham Lloyd has said (op. cit., p. 306), " Medicine is in grave danger of being overwhelmed by the facts it has already accumulated, and what is needed is the means of applying its available knowledge."

Most of this book has been devoted to a brief account of the pre-scientific days of Medicine ; to the great discoveries which form landmarks in its evolution, and to discussing the debt we owe to the exact sciences from which these discoveries have originated.

At the same time I have ventured to suggest that running through its history, its discoveries, and its practice, there is a touch of romance which appeals to the imagination and adds to their interest. To the doctor who is conscious of its presence in his daily life, it brings an additional zest to his work, and eases the burden ; and the same may be said of the very occasional gleams which appear in medical literature and in no way diminish their scientific value to the reader. To the stern critic who frowns on any play of fancy in a book dealing with Medicine, the only reply is a reference to the " primrose by the river's brim " (page 259).

To those who maintain that if Medicine got its way in all it proposes to do, or might do, society would be turned upside down ; that there are matters of greater import than safeguarding our health ; and that on the social, economic and political sides such projects are mere chimera. Perhaps to these, our best reply would be :

> Ah ! but a man's reach should exceed his grasp,
> or what's a heaven for ?

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